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The impact of CCPs' margin policies on repo markets *

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Abstract

This paper quantifies the impact on the cost of funding in repo markets of the initial margins applied by central clearing counterparties (CCPs). We use contract-level data on the general collateral (GC) segment of Italy's MTS Repo market between January 2011 and April 2014. The analysis shows that the initial margins, paid by all participants, had a positive and significant effect on the cost of funding. Such an impact is consistent across different model specifications and data subsamples.

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*The opinions expressed are those of the authors and do not necessarily reflect those of Bank of Italy or the Bank for International Settlements.

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1 Introduction

Starting in mid-2007, heightened concerns about counterparty credit risk and increased demand for liquidity led to significant disruptions in money markets. In the euro area, financing activity shifted to the secured segment of the money market in the wake of a severe impairment of the unsecured segment. Since then, despite a large number of monetary policy measures, the proper functioning of euro money markets has not been completely restored, and the preference for secured transactions continues to be widespread (see ECB (2014a)).[1] In the euro area, the secured segment currently represents the largest share of the money markets, with transactions increasingly cleared through central clearing counterparties (CCPs).[2] The estimated outstanding volume of repos and reverse repos currently amounts to about EUR 5.5 trillion (see ICMA (2015)).[3]

Trading activity on Italy's interbank market has followed similar trends. While unsecured trades have dropped off over time, stabilising at very low levels, the collateralised ones have steadily increased, now accounting for the largest share of money market transactions. In 2014, daily repo volumes on the MTS Repo platform amounted, on average, to about EUR 84 billion (up from EUR 82 billion in 2013), about 40 times the average turnover on the electronic unsecured market e-MID. These transactions were almost entirely cleared through two CCPs: Cassa di Compensazione e Garanzia (CC&G) and LCH Clearnet SA (LCH), used, respectively, by Italian and foreign financial institutions.[4]

In response to the growing reliance on central clearing, authorities have required CCPs to strengthen their risk monitoring and management systems, thereby enhancing their resilience (see CPSS-IOSCO (2012); EMIR (2012)). Following this regulatory push, as well as increased volatility in Italian government bonds prices, both CC&G and LCH have moved to revise their initial margin policy. Although margin increases are expected to strengthen CCPs'

[1]Recent data on the euro money markets indicate that trading on secured markets continues to account for the largest share of money market transactions, with cumulative turnover in the secured segment being almost 10 times the volume in the unsecured segment (see ECB (2014a)).

[2]Centrally cleared contracts currently represent about 70% of all repo transactions (see ECB (2014a)). As such practice is not mandatory for market participants, it is likely to reflect the fact that in secured transactions too, and especially in times of heightened volatility, market participants are concerned with counterparties' creditworthiness (see CPSS (2010)).

[3]The magnitude of this number is comparable with the estimate available for the United States of about USD 5.5 trillion (see Copeland et al. (2012)). Nonetheless, the two markets look quite different in terms of microstructure, infrastructure and financial operators active (ICMA (2014); FSB (2012); ECB (2012)). In contrast to the United States, where most repo transactions are part of the shadow banking system (see Acharya and Öncü (2012)), the majority of euro repo transactions are conducted in the interbank market, reflecting the dominating role of banks in the European financial sector. Moreover, the largest part of interbank repo transactions in the euro area is centrally cleared (see ECB (2014a)).

[4]This is the only case in the euro area where two CCPs have entered into an interoperability agreement to serve a common market (see Bank of Italy (2014a); Bank of Italy (2014b)).

resilience, procyclical upward adjustments could determine disruptive second-round effects on the underlying markets.[5] Downward changes might also have procyclical effects, fostering leverage growth, as confirmed by the work of the Financial Stability Board (FSB) to introduce minimum haircut levels in repo trades (see FSB (2013); FSB (2014)).[6] Despite this broad agreement by academics and policymakers on the procyclical effects of margin changes, the limited availability of detailed data on repo markets has somehow constrained the extent of the analysis.

In this paper, we explore the impact of CCPs' initial margin policies on the cost of funding, drawing on an extensive transaction-level data set on the Italian MTS Repo market (general collateral segment), collected by the Bank of Italy for supervisory purposes. To the best of our knowledge, this is the first study that quantitatively assesses the impact of CCPs' initial margin policies on the cost of funding. Overall, our analysis attempts to contribute to the policy debate on the potential impact of regulatory reforms both in the field of financial market infrastructures and of securities financing transactions.

The analysis provides the following evidence: initial margins, paid by all participants, have a significant and positive effect on the cost of funding observed on the general collateral (GC) segment of the Italian MTS Repo market; on average, the impact is equal to about 3-4 basis points for a 100 basis point variation in the margin. Although our estimate relies on simplifying assumptions,[7] it is valuable as it sheds some light on how the market functions. The impact of margins rises with higher quantiles of the distribution in the cost of funding: a 100 basis point increase in the initial margin translates into a change in the cost of funding, ranging between 2 and 4 basis points, respectively, for the lower and upper tail of the distribution. Lastly, we perform a counterfactual exercise and find that if margins were kept at the pre-crisis level, the average spread between Italian repo rates and the European benchmark in our sample would have fallen from an average of 12.1 basis points to 1.5, or to 5.8 basis points (when using, respectively, an OLS or a quantile regression on the median).

The remainder of the paper is structured as follows: Section 2 briefly reviews the main literature on repo markets, as well as on CCPs. Section 3 introduces the role of CCPs in repo markets and the basic functioning of Italy's MTS Repo market; a short overview of the

[5] To limit procyclical effects, CCPs are requested to establish stable and conservative margins that are , as far as possible, precalibrated to allow for stressed market conditions (see CPSS-IOSCO (2012)). Nevertheless, the transition to a state where margins are stable and conservative might require upward adjustments, with potential procyclical effects.

[6] Since the Great Financial Crisis, a common view is that, in bilateral transactions, the low haircut levels observed before the crisis deepened likely contributed to a surge in leverage and asset prices, while their subsequent increases have exacerbated the crisis, generating harmful procyclical effects (see CGFS (2010)).

[7] Our estimate reflects the level of initial margins only, and not the monetary cost of their refinancing on the market.

main changes in the CCPs' risk management frameworks for MTS Repo is also provided. In Section 4, an analytical example is introduced to show the relationship between the cost of funding and initial margins. Section 5 describes the data and the econometric specification. Section 6 illustrates the results, and Section 7 concludes.

2 Literature review

Following the Great Financial Crisis, academics and policymakers started to take a renewed interest in repo markets. While pre-crisis studies related more to asset pricing issues (see Duffie (1996); Jordan and Jordan (1997); Buraschi and Menini (2002)), the most recent ones have adopted a financial stability perspective with special attention paid to the functioning of repo markets, as well as the role they played in the propagation of the crisis and their impact on financial stability. Much of this literature has focused on the effects that changes in margins and haircuts can have on financial markets. New insights have emerged about the potentially adverse consequences of secured funding, with a particular focus on procyclical liquidity and leverage cycles. In Brunnermeier and Pedersen (2009), when negative shocks hit, procyclical margins can contribute to a "destabilizing" effect on market liquidity. Valderrama (2015) argues that the correlation between asset returns and funding costs, resulting from daily re-margining practices,[8] may exacerbate systemic risk, and help to turn liquidity shocks into solvency shocks by shifting market risks from lenders to borrowers.[9] A number of complementary studies have expanded on this argument, discussing how margin requirements could be used as a macroprudential tool by policymakers to restrict risk-taking and the build-up of excessive leverage (Gai et al. (2011); Goodhart et al. (2012); Brumm et al. (2013); Stein (2012); Biais et al. (2012)).

In contrast, empirical studies on repo markets have so far been limited, most likely due to the scarcity of granular data. Most of the empirical evidence is related to the US market, with few studies of other countries or regions. Gorton and Metrick (2012) show that, during the crisis, increasing concerns about the quality of the collateral used in the US repo market led to abrupt increases in bilateral margins, which dramatically reduced trading volumes ("run on repo"). Krishnamurthy et al. (2014) claim that the run observed during the crisis resembled more a simple credit crunch than the analogue of a traditional bank run by depositors, as balance sheet-constrained dealers simply tightened the terms of trades by increasing margins.

[8] Daily marking to market of the outstanding positions determines the recalibration of the margins ("re-margining"), possibly leading to additional margin calls.

[9] Other papers on this topic include Gârleanu and Pedersen (2011), Rytchkov (2014) and Acharya, Gale, and Yorulmazer (2011).

Given the differences in repo markets across jurisdictions, it would be inappropriate to merely extend the results of the abovementioned empirical studies - focused on the US repo market - to a European one, since specific institutional features may, in fact, shape the dynamics observed in each repo market. In contrast to what happened in the United States, Mancini et al. (2014) show that the CCP-cleared euro repo market proved remarkably resilient during the financial crisis, and that, when backed by high-quality collateral, it also acted as a shock absorber as repo lending activity increased in line with risk perceptions. By using GC transactions operated on the Eurex Repo platform, they show that higher risk increases trading turnover, with practically no effect on repo rates and maturities.[10] Moreover,the paper finds that central bank excess liquidity can negatively impact both repo rates - up to a saturation threshold (of approximately EUR 300 billion) - and repo volumes.[11] In contrast with that paper, Boissel et al. (2014) find that the perception in euro area markets on the protection offered by CCPs against sovereign stress changed over time. While in the period 2009-2010 market participants believed that CCPs offered full protection against sovereign stress in the repo market, in 2011, at the peak of the crisis, this belief changed, and CCP-intermediated repo markets turned to be vulnerable to sovereign risk. In addition, Boissel et al. (2014) find that repo rates responded to movements in sovereign risk, in particular at the peak of the crisis and in countries where the stress was more acute.

As already mentioned, the extensive use of CCPs by market participants is a very important aspect of the repo market, especially in the euro area. Following the crisis, a surge of academic interest on central clearing has been recorded, also because regulatory reforms in the area of OTC derivatives, as well as persistent risk-aversion, have shifted an increasing share of financial trades towards central clearing. Much theoretical literature has focused on models aimed at analysing the optimal design of incentive-compatible clearing arrangements, highlighting the possible emergence of a trade-off between improved risk-sharing (between each market participant and the CCP) and moral hazard (Biais et al. (2012); Koeppl et al. (2012); Acharya and Bisin (2014)). Overall, the impact of CCPs on welfare and systemic risk is still unclear (see Coeuré (2014)): while CCPs may provide benefits in terms of financial stability, by reducing, for example, counterparty risk (IMF (2010); Acharya and Bisin (2014)), they may also impose sizeable costs due to the consequent upsurge in the demand

[10] The paper uses data on Eurex General Collateral pooling transactions. The GC pooling basket is based on the Eligible Assets Database (EAD), used by the ECB for open market operations. This basket enables the re-use of received collateral for refinancing. It comprises securities rated as at least upper medium grade (ie A-/A3), subject to a number of further restrictions. Robustness checks and cross-sectional comparisons across collateral types are performed relying on BrokerTec and MTS GC and special repo data. Overall, they confirm the authors' findings.

[11] The availability of abundant liquidity, supplied on relatively attractive terms, promotes a "substitution effect" between "private" and "public" liquidity (see Bolton et al. (2009)).

for collateral (see Singh (2010)) and the concentration of risks. A recent study (see Abruzzo and Park (2014)) has instead investigated the relationship between margin level changes and volatility in the futures market, finding that margins rapidly increase after volatility spikes, but do not suddenly release afterwards, thus implying non-linear, procyclical dynamics.

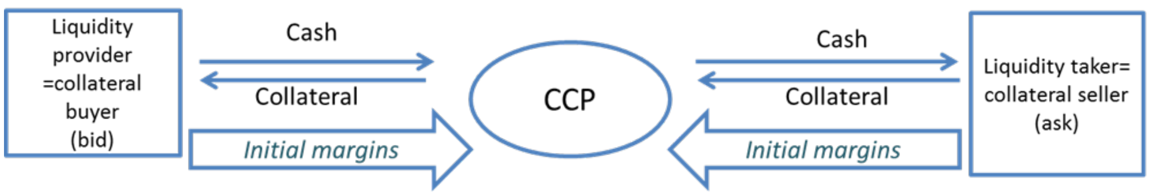
Our paper builds largely on the economic literature related to the functioning of repo markets. Nonetheless, given the relevance of CCPs, we also look at the role and incentives provided by CCPs to their members. In particular, our analysis attempts to merge the abovementioned streams of literature by exploring the links between CCPs' risk management policies and dynamics in repo markets. To this end, we use a comprehensive database on repo trading activity to quantitatively assess the impact of CCPs' initial margin policies on the cost of funding in repo markets. To the best of our knowledge, this is the first study that offers a quantitative investigation of this effect. Overall, our analysis seeks to contribute to the ongoing debate on the potential impact of regulatory reforms, in the fields of both financial market infrastructure and of securities financing transactions.

3 The repo market and the role of CCPs

A repo (also known as a "repurchase agreement") is a transaction between two parties, in which one party borrows cash from the other by pledging a financial security as collateral. Seen from a different perspective, a repo transaction implies the temporary sale of a security at a spot price and the agreement to buy back the same security at a specified price and date in the future; the difference between the spot and the forward prices defines the repo rate. In the repo markets, loans can be extended for different maturities, ranging from short (eg overnight, tom-next and spot-next repos) to longer terms (eg from one week up to one year). There are two types of repo contracts, distinguished by the assets used to secure the exchange of liquidity. In GC repos, the collateral is a security discretionally chosen among a large basket of bonds usually issued by central governments or corporates. By contrast, in special repos (SRs) liquidity is exchanged against a specific asset demanded as collateral. Different economic reasons drive investors' choice to trade in either one or the other segment: while GC repos are typically used to cover funding needs (cash-driven transactions), SRs usually provide for the temporary loan of specific bonds (security-driven transactions) and may be part of short-selling strategies. The rate on SRs is generally lower than the one on GC repos, reflecting the premium attached to a specific bond, because the cash-rich counterparty is willing to pay a premium to temporarily dispose of that particular security.

Repos on Italian government bonds can be traded electronically on Italy's MTS Repo platform. In GC transactions executed on this system, funds can be exchanged against any security included in a basket of Italian government bonds comprising the full range of Italian government issues; in these trades, the liquidity taker selects the security pledged as collateral within two hours following the conclusion of the trade. By contrast, in SRs, precisely determined Italian government bonds collateralise the exchange of funds. Following the crisis, trading on Italy's MTS Repo platform increased remarkably. In 2014, daily volumes on the market amounted, on average, to about EUR 84 billion (up from EUR 82 billion the year before); SRs accounted for the largest part (67%) of the contracts over the same period. Notably, over about 95% of these transactions were cleared through the use of the two CCPs active on this market, namely CC&G and LCH, used, respectively, by Italian and foreign financial institutions (see Bank of Italy (2014b)).

As already noted, market participants have made a larger use of the clearing services offered by CCPs in recent years due to regulatory developments as well as enduring risk aversion in financial markets (see CPSS-IOSCO (2012); EMIR (2012)). The advantages that central clearing offers to market participants relate primarily to counterparty risk reduction and to cash and collateral savings through multilateral netting. Nonetheless, participating in a CCP entails some costs, such as annual participation fees, contributions to the default fund and the payment of initial and variation margins. In centrally cleared repo transactions, CCPs require both parties (ie the liquidity taker and the liquidity provider) to post initial margins with the CCP on the net amount of the collateral due, with the aim of providing the CCPs with sufficient resources to mitigate potential risks (see Graph 1).[12] In contrast to bilateral trades where liquidity takers only pay haircuts, in CCP-cleared contracts, margins represent a cost for both liquidity takers and liquidity providers. In addition, participants may be asked, at least daily, to post variation margins following mark-to-market valuation of individual positions vis-à-vis the CCP.



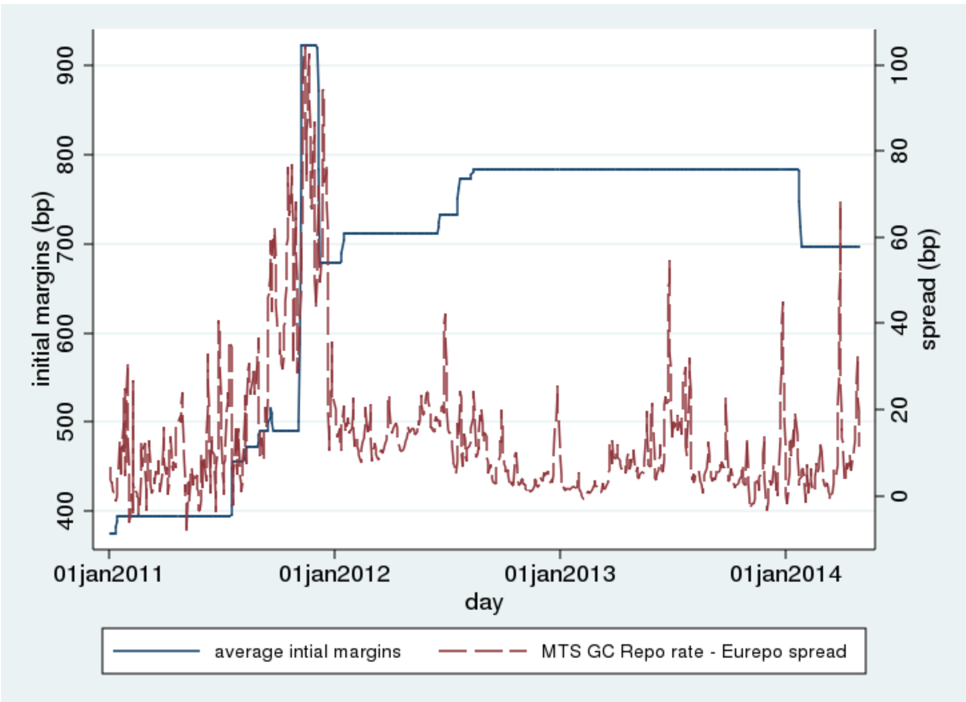
Graph 1: margins' provision in a CCP-cleared repo

Given the significant reliance of market participants on clearing services, the MTS Repo

[12]CCPs use the margins posted by liquidity providers to cover themselves against the risks of: (i) collateral not being refunded; and (ii) insufficient cash to buy the collateral on the market. On the other hand, CCPs use the margins posted by liquidity takers to cover themselves against the risks of: (i) cash not being refunded; and (ii) the inability to realise the collateral on the market for the same amount.

market is potentially sensitive to the risk management policies adopted by CCPs. In recent years, both CC&G and LCH have progressively refined their risk management policies following the regulatory push to enhance CCPs' resiliency. At the same time, the generalised increase in sovereign risks has led CCPs to raise their initial margins with a view to increasing their protection vis-à-vis their credit exposures to participants.

On 9 November 2011, in order to better manage sovereign risk, the risk management framework was made more responsive to the spread between Italian and European benchmark securities. As a consequence, the increase in initial margin requirements on positions collateralised by Italian government securities across all duration buckets ranged between 3.5% and 5%. These increases were partially reversed in December 2011 (see Graph 2). The remarkable margin change observed in late 2011 was associated with a spike in the cost of funding, which was especially driven by a sharp increase in the Italian repo rate. In the following sections, we first show - on theoretical grounds - that a causal relationship between margins and the cost of funding exists; then we empirically test and quantify it using data on the Italian MTS Repo market.



Graph 2: Average margins and spreads on the Italian Repo Market

Note: In the graph, a daily average of initial margins applied to different maturity buckets are plotted (solid blue line, left-hand scale) along with the daily average spread between MTS GC Repo rates and Eurepo (red dashed line, right-hand scale). Data are in basis points.

4 A model of margining

To see the link between margins and the cost of funding, we develop a stylised model of CCP-cleared secured transactions. The main purpose of the model is to show that, in a repo market, where initial margins are paid both by liquidity takers and providers, an increase in margins leads to a higher cost of funding and to lower quantities exchanged. In the model, we will present a positive relationship between the margins and the repo rate - while, in the subsequent empirical exercise, we will focus on the relationship between margins and the cost of funding (ie the spread between the interest rate of the repo trade and the corresponding Eurepo rate[13]). Under the assumption of an invariant Eurepo rate, the rate and the spread would be perfectly collinear; thus an increase in the repo rate would fully translate into a higher cost of funding.[14]

The model lasts two periods, $t = 1, 2$, and involves two risk neutral agents, a "liquidity taker", T, and "liquidity provider", P.[15] The liquidity taker is endowed with K units of a risk free zero-coupon bond, whose value in period 1 is 1 and whose gross return in period 2 is $R > 1$ per unit. There is no secondary market for the security, but we assume it can be pledged as collateral in a repo contract. The liquidity provider, instead, has a monetary endowment Y. The liquidity taker and provider differ also in their discount rates. In particular we assume that the liquidity taker is more impatient than the provider: $\beta^T > \beta^P$, with $\beta^P, \beta^T \in (0, 1)$.

The economy starts with no contracts in place. The agents enter into a repo contract in which the liquidity taker receives a cash amount $d > 0$ in period 1 and promises to repay $(1+r)d$ in period 2, where r is the repo rate of the contract.[16] We assume that exchanges are collateralized and take place through a CCP. It is also assumed that the liquidity taker cannot borrow more than the current value of the available collateral K net of the margin paid md, so that the borrowing constraint writes $d \leq K - md$. The existence of the borrowing constraint is due to the risk management policies of the CCP (see Section 3).[17] Both the liquidity taker

[13] The European Money Markets Institute defines the Eurepo as "*the rate at which, at 11.00 am Brussels time, one bank offers, in the euro-zone and worldwide, funds in euro to another bank if in exchange the former receives from the latter the best collateral within the most actively traded European repo market*". The range of maturities quoted by panel banks are the following: tomorrow-next, up to one month (ie one/two/three weeks), and one month and beyond (one/two/three/six/nine and 12 months).

[14] In the theoretical model, there is no "benchmark" rate, as the only repo rate is the one on the contract. We could, nonetheless, introduce a reference rate, but this would not be affected by margin variations on the specific contract. Therefore, the results would seamlessly apply.

[15] We model agents' utility as linear, thus implying risk neutrality. This assumption is introduced in order to work with simple, closed-form, expressions. All the qualitative results of the model apply with any standard utility function.

[16] Despite both assets (the bond and the repo loan) being risk-free, the gross return on the bond R differs from the repo rate r because we assume the existence of the repo market, but not of a secondary cash market for the bond. As a consequence, R embeds a liquidity premium that r doesn't include.

[17] An alternative assumption would be that the liquidity taker cannot borrow more than the value of the

and the provider have to post initial margins $m \in (0,1)$ to the CCP, which are going to be rebated in period 2.

Therefore, the problem for the liquidity taker is:

$$
\begin{aligned}
& \max_{c_1^T, c_2^T} c_1^T + \beta^T c_2^T \\
\text{s.t.} \quad & c_1^T + md = d \\
& c_2^T + (1+r)d = RK + md \\
& d \leq K - md \qquad (1)
\end{aligned}
$$

where $c_1^T, c_2^T > 0$ relate to the consumption of the liquidity taker either in period 1 or 2. The demand for repo funds is then easily derived. When the collateral constraint is slack, the Euler equation for the liquidity taker implies:

$$
r^T = \frac{1-\beta^T}{\beta^T}(1-m). \qquad (2)
$$

When the constraint is binding, the demand for repo funds is directly derived from (1), therefore:

$$
d^T = \begin{cases} 0 & \text{if } r > r^T \\ [0, d^*] & \text{if } r = r^T \\ d^* & \text{if } r < r^T \end{cases} \qquad (3)
$$

where $d^* \equiv \frac{K}{1+m}$. Demand is downwards-sloping and has kinks at points 0 and d^*. Note that r^T is negatively related with the margin paid: when margins increase, the liquidity taker seeks compensation - through a lower rate - to the decrease in consumption today (which is not fully compensated by consumption tomorrow, due to the discount rate).

From point d^* on, the liquidity taker's demand is constrained by its collateral endowment and by the margin paid: any increase in margins shifts the constraint to the left, thus mechanically reducing the maximal amount of liquidity that can be borrowed by the liquidity taker.

In a similar vein, the problem for the liquidity provider is:

asset in period 2, net of the return accrued on d, ie $(1+r)d \leq RK - md$. This alternative assumption would lead to identical results in terms of the impact of margins on rates and quantities exchanged.

$$
\begin{aligned}
&\max_{c_1^P, c_2^P} c_1^P + \beta^P c_2^P \\
\text{s.t.} \quad & c_1^P + d + md = Y \\
& c_2^P = (1+r)d + md
\end{aligned}
\tag{4}
$$

with $c_1^P, c_2^P > 0$ In this case, the first-order conditions w.r.t. d give us the supply of repo funds:

$$1 + m = \beta(1 + r + m) \tag{5}$$

This implies that:

$$r^P = \frac{1 - \beta^P}{\beta^P}(1 + m). \tag{6}$$

Hence the supply schedule writes:

$$d^P = \begin{cases} 0 & \text{if } r < r^P \\ [0, \frac{Y}{1+m}] & \text{if } r = r^P \\ \frac{Y}{1+m} & \text{if } r > r^P \end{cases} \tag{7}$$

where it can be noted that in this case - in contrast with the liquidity taker, but for the very same argument - an increase in margins leads to an upward shift of the horizontal part of the supply schedule. Indeed, when margins increase, the liquidity provider seeks compensation through the rate for the fact that he can lend less (and thus earn less in period 2).[18]

The effects of a shift in margins can be easily seen through a graphical representation of the equilibrium (see Graph 3). Suppose, for the sake of simplicity, that the equilibrium is at point E: an increase in margins implies an upward shift in the rate at which funds are offered, along with a reduction of the total funds available. At the same time, it will tighten the collateral constraint (1), thus shifting the vertical part of the demand backwards up to the point d', while the horizontal part will shift downwards with a reduction in the demanded rate.

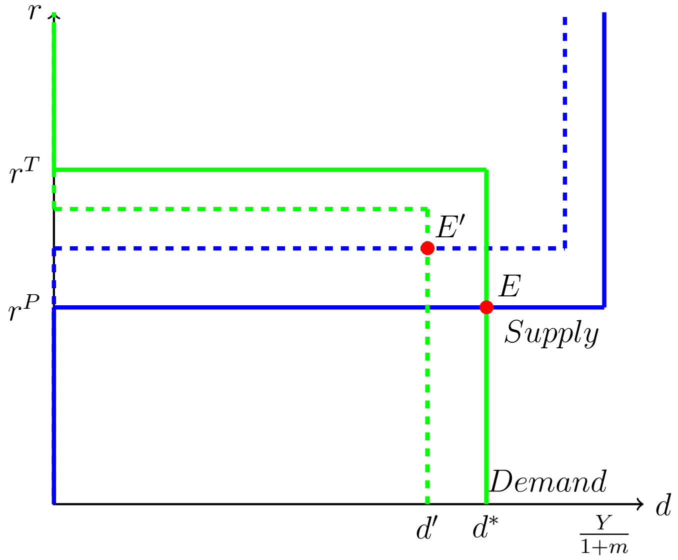
[18]Note that to get an equilibrium with a strictly positive amount of funds traded we need $r^T \geq r^P$. This implies a restriction on parameters. More precisely, this requires that

$$r^T = \frac{1 - \beta^T}{\beta^T}(1 - m) \geq \frac{1 - \beta^P}{\beta^P}(1 + m) = r^P \tag{8}$$

or, after some manipulation

$$\frac{\beta^P}{\beta^T} \geq \frac{1 + m(1 - \beta^P)}{1 - m(1 - \beta^T)}. \tag{9}$$

The new equilibrium will be at point E', thus implying a lower quantity of funds exchanged at a higher rate after the increase in initial margins.



Graph 3: Equilibrium in the repo market

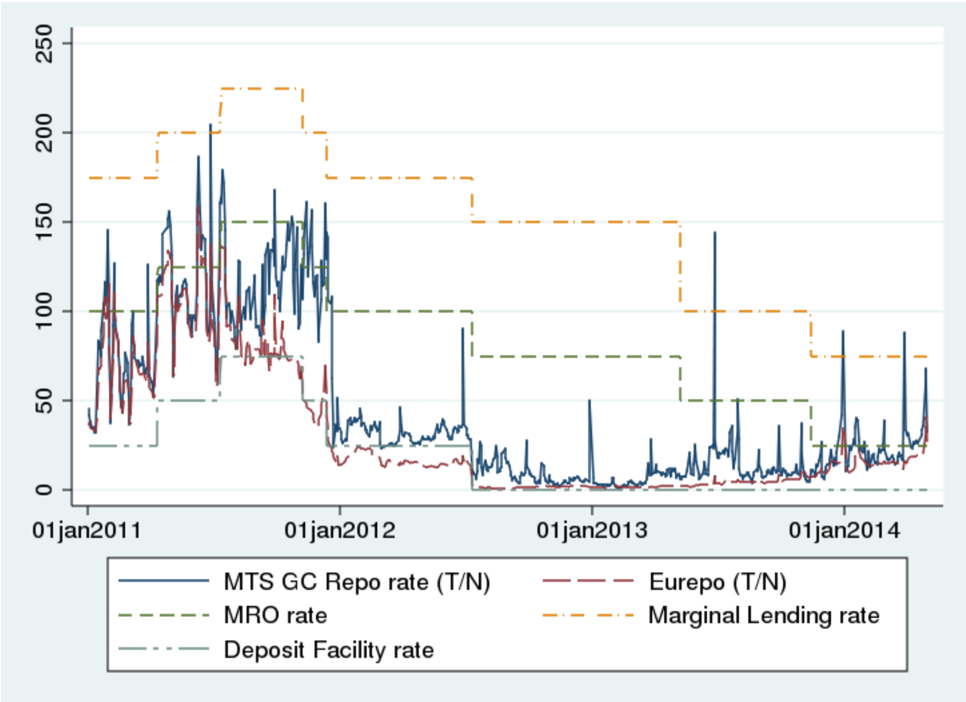
5 Data and empirical analysis

The main data set is constituted by GC repo transactions executed on Italy's MTS Repo trading platform, from 3 January 2011 to 16 April 2014; this information is collected by the Bank of Italy for supervisory purposes (see Table 1). The data set contains transaction-level information, including the trading volume, the repo rate, the collateral and the maturity of the contract; it also details whether the contract was CCP-cleared and which party provided the service (ie CC&G or LCH). Italian government securities only are eligible as collateral to secure transactions on this market; BTPs and BOTs account for the highest share of bonds pledged.[19] Contracts traded cover different maturities, though most are very short. As we are pooling together different maturities in our data set, the estimated coefficients in the empirical analysis must be interpreted as the effect of the covariates on an "average" maturity, and not on any specific maturity.

In our setting, the cost of funding on the Italian MTS Repo market is measured using the spread between the Italy's MTS GC rate and the Eurepo rate. The use of spreads is not new in this literature, though the definition has been formulated according to the purpose of the analysis (Taylor and Williams (2009) and Mancini et al. (2014)). In our case, the spread measure intends to capture the differential cost of financing repo transactions by making use

[19]BTPs are medium/long-term treasury bonds, while BOTs are short-term securities with maturities up to one year.

of Italian government bond collateral, rather than of the "*best collateral actively traded on European repo market*"



Graph 4: MTS repo rate, Eurepo and monetary policy rates

Note: In this graph, the daily average of the repo rate for the tom-next maturity is plotted along with the Eurepo rate for the same maturity bucket and the ECB policy rates (daily data; basis points).

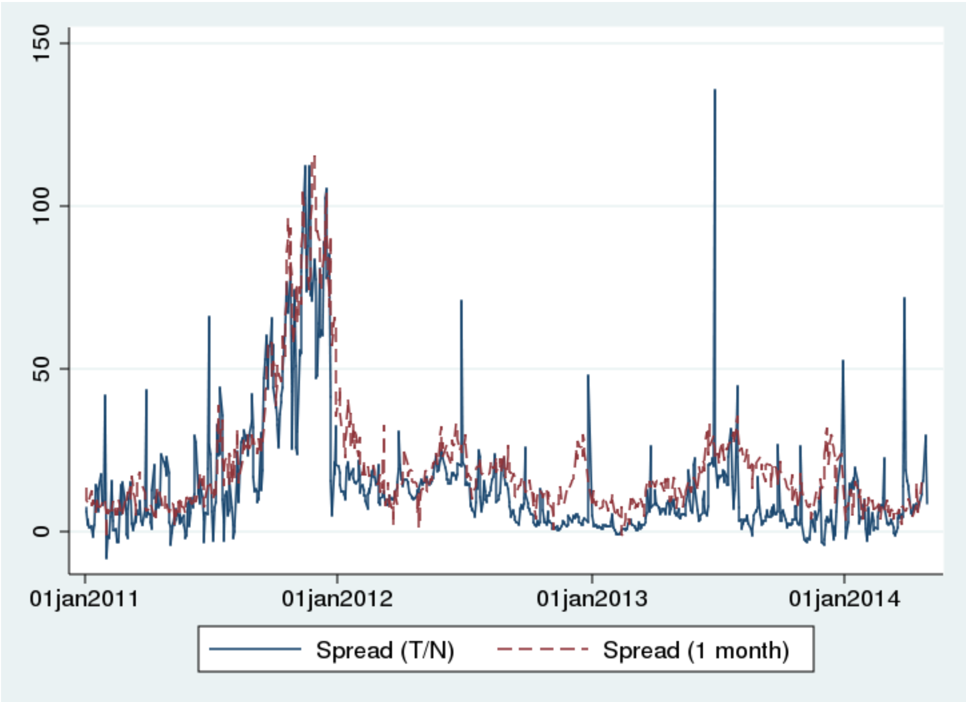
Our dependent variable is constructed as follows:

$$s_{i,t} = rate_{i,t} - Eurepo_t \tag{10}$$

where $rate_{i,t}$ is the rate negotiated on contract i, executed on the Italy's MTS Repo market on day t, while $Eurepo_t$ is the Eurepo rate quoted on day t of the corresponding maturity. Both rates refer to GC repo trades. Three caveats apply to the measure defined above. First, the Eurepo is an offer-rate only, which is compared with effectively traded rates that could stem either from a bid or an ask proposal. Second, submitted Eurepo rates may correspond to either bilateral or centrally cleared transactions, while for $rate_{i,t}$ we consider only the latter. Third, the Eurepo rate is a benchmark rate for the whole euro zone corresponding to the best quotes submitted daily by a panel of banks, while we take into account rates effectively negotiated on a single market by all participating banks.[20] Although this measure

[20]We can not exclude that variation in Eurepo rates could also reflect movements in CCP margins. To the extent that there might be positive correlation in margin changes throughout CCP-cleared European repo markets backed by Italian government securities, the use of a spread as a dependent variable could hide some confounding factors. However, this potential bias is, in our view, mitigated by the fact that Eurepo rates

may present some bias, it is, in our view, the best approximation available for our purposes.[21] The evolution of such a variable is represented in Graph 5, where we plot a daily average of the spreads corresponding to two different maturities: tomorrow-next (T/N) and one month.



Graph 5: Spreads MTS Repo - Eurepo

Note: In the graph, the MTS Repo Rate-Eurepo spreads are plotted for the tom-next maturity (blue solid line) and for the one-month maturity (red dashed line). Data are in basis points.

In both cases a gradual increase can be seen in the second half of 2011, followed by a relatively sharp contraction at the beginning of 2012. As one would expect, the T/N spread is more volatile than the one-month spread, with temporary peaks due to liquidity pressures occurring on specific trading days. Over the period considered, the average spread variable, weighted by the volume and the maturity of the contract, is equal to 12 basis points (see Table 2). Our empirical approach implies that spreads $s_{i,t}$ are regressed on initial margins and on a broad set of explanatory variables. For the purpose of our analysis, we select only CCP-cleared contracts, with a "standard" maturity and a corresponding Eurepo rate[22]

reflect not only centrally cleared transactions but also bilateral ones, for which this correlation bias could admittedly be negligible. In addition, given that it is set with reference to the "best collateral actively traded on the market", and not to a specific market backed by Italian collateral, it is reasonable to expect lower volatility.

[21] As an alternative to the Eurepo rate, we have also used the RepoFundsRate. In this case too, there is a certain degree of approximation deriving from the use of an index. This one builds on repo trades, secured by general or special collateral, executed on either the BrokerTec or the MTS platform. All eligible trades are centrally cleared and maturities are short-term only (overnight, tom-next or spot-next). The results of the empirical analysis for short-term transactions only are robust to the choice of the index.

[22] We exclude non-standard maturities proposed on the electronic platform (so called "broken dates", eg one week plus two days).

(see Table 1); we make an exception to the last criterion, retaining also overnight and spot-next contracts, as they account for about 60% of transactions.[23] Overall, we have a total of 470,346 trades, essentially concentrated on short maturities, reaching an average daily trading volume of EUR 42 billion; cross-border transactions, which make use of the interoperability agreement between CC&G and LCH, account for the largest share of the monthly average of daily volumes.

We estimate a reduced-form baseline equation, which reads as follows:[24]

$$s_{i,t} = \alpha + \beta_1 mar_t + \beta_2 X_{t-1}^{mkt} + \beta_3 X_{i,t}^{repos} + \eta_j + \varepsilon_{i,t} \tag{11}$$

where:

- mar_t is the daily average level of margins weighted by the outstanding government debt amount for each bucket of duration. In a GC repo, the liquidity provider concludes the contract in the uncertainty of the exact security that she will receive as collateral and thus of the exact margin level that she will have to pay. Indeed, following the conclusion of the contract, the liquidity taker has a time span of two hours to select the specific security to guarantee the transaction. In this light, we introduce in the regression an average margin across maturity buckets, which is not contract-specific, but is intended to represent a proxy for the expectation of the liquidity provider about the initial margin to be paid.[25]

- X_{t-1}^{mkt} is a vector of variables capturing aggregate risk and, specifically, credit and liquidity risk, pointing ultimately to collateral quality uncertainty. To avoid co-movement between spreads and aggregate risk indicators under the same shocks, we consider the latter lagged by one day. To avoid correlation between the average margin level and the aggregate risk vector, we discard risk measures that are considered by the two CCPs'

[23] Eurepo rates for overnight and spot-next contracts are not quoted. Nonetheless, we interpolate these rates from the official quotes provided on T/N maturity. Therefore the following maturities are considered in the analysis: one day (overnight, tom-next, spot-next), up to one month (one-, two- and three-weeks), one-month and beyond (one-, two-, three-, six-, nine-months and one-year). Overall, the contracts excluded represent a negligible share in our sample.

[24] It is recalled that $s_{i,t}$ represents the spread negotiated on contract i, executed on the Italy's MTS Repo market on day t; fixed effects are introduced at the level of the liquidity provider. Descriptive statistics are reported in Table 2.

[25] The amount of initial margin to be paid depends on the duration of the security received as collateral; it is computed considering the net exposure in the correspondent duration bucket. Each trade triggers a change in the net exposure of one duration bucket and consequently an initial margin call. However, given the liquidity provider's uncertainty of what collateral she is going to receive and of the duration bucket on which her net exposures will change, we simplify our setting considering the impact of initial margins directly on individual transaction rates.

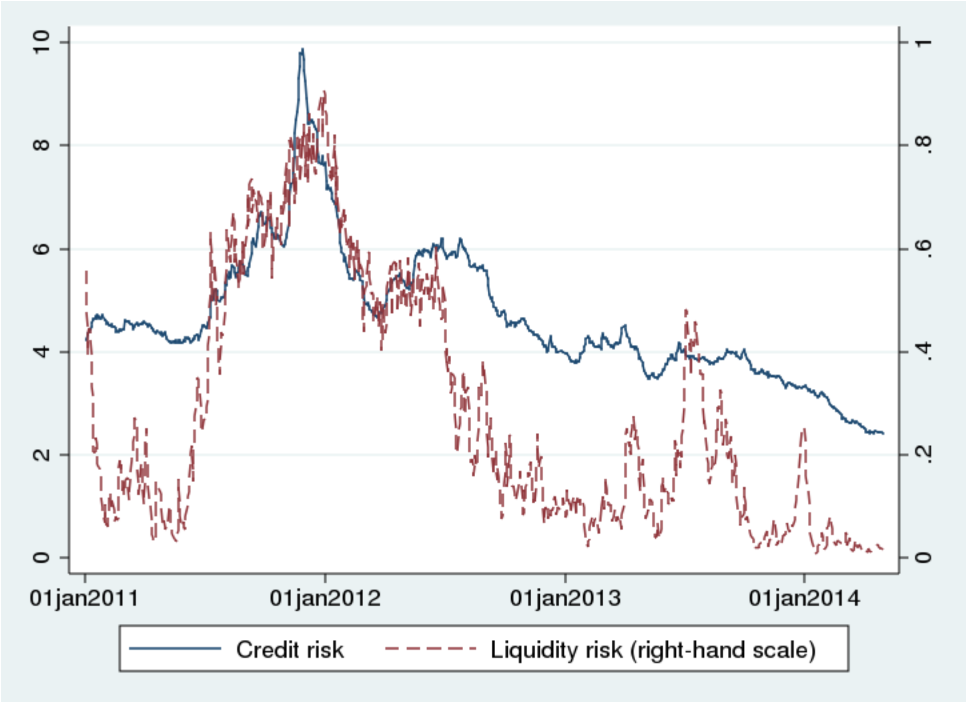
joint margining methodology. Our measure of credit risk relies on the methodology developed by Gilchrist and Mojon (2014) and focuses on the Italian banking system.[26] In comparison with alternative market-based credit risk indicators (eg CDS spreads and iTraxx), this measure builds on a very large cross section of issuers, thus providing a more informative indication of financial distress. Furthermore, to control for liquidity risk on Italian financial markets, we make use of a systemic indicator developed at the Bank of Italy (see Iachini and Nobili (2014)). This measure, ranging between 1 and 0, builds on a set of market variables selected to capture the intensity of liquidity distress in the most important segments of the Italian financial markets (the equity and corporate market, the Italian government bond market and the money market). The dynamics of the indicators are shown in Graph 6. Both credit and liquidity risk on the Italian financial markets increased sharply in the second half of 2011, gradually declining thereafter; in 2014, both metrics returned to very low levels, signalling the easing of tensions seen in financial markets in the first half of 2014. Over the period considered, the correlation between the two indicators is high and significant (0.84; Table 3), although they reflect different phenomena on financial markets. Indeed, although correlation across the whole sample is strong, the dynamics of the two indicators tend to diverge in subsamples. To see this, in Graph 7 we plot rolling-window correlations among the two variables. It can be seen that in several occasions there was no (or even negative) correlation between the two variables. We also experimented with alternative indicators of riskiness and market volatility (VIX, CISS index etc) confirming the robustness of our estimates.[27]

- X_t^{repos} is a vector of variables capturing market conditions affecting the repo market each day, as well as idiosyncratic features for each contract. In particular, we consider the following variables: (i) the excess liquidity for the euro area, computed as the sum of the deposit facility net of the recourse to the marginal lending facility, plus the current account holdings in excess of those contributing to the minimum reserve requirements (see ECB (2014b)); and (ii) the dummy variables capturing potential idiosyncratic pressure in liquidity markets to account for spikes in risk premia (Italian fiscal due dates, the end-of-month and end-of-quarter window-dressing effects).[28] Additional controls re-

[26] In Gilchrist and Mojon (2014), the measure for the credit spread is constructed at the bond level as the yield difference between corporate bonds and German Bund zero coupon bonds of the same maturity. These bond-level credit spreads are then aggregated to obtain credit risk indices at both the sector and country level. The updated time series can be found at www.banque-france.fr/en/economics-statistics/research/working-paper-series/document/482-1.html.

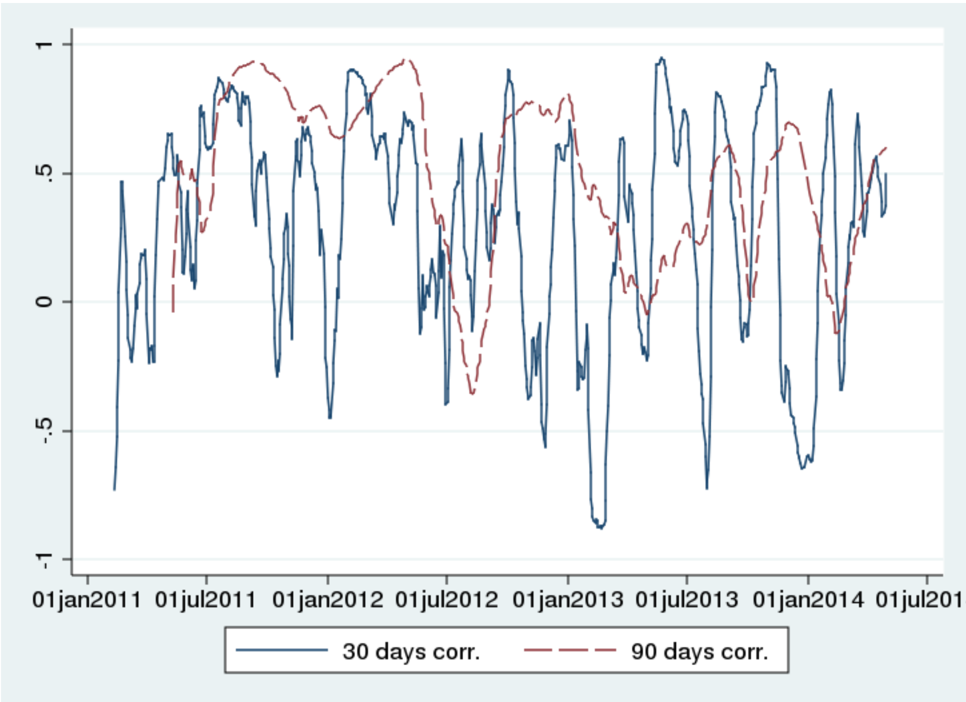
[27] Results are available on request.

[28] Dummies for the end-of-maintenance-period are not significant, presumably because in the period considered (3 January 2011-16 April 2014) the amount of liquidity injected into the system was particularly high;



Graph 6: Credit risk and liquidity indicators

Note: In the graph, the Gilchrist and Mojon (2014) credit risk indicator for the Italian banking sector (blue solid line, per cent left-hand scale) is plotted along with the Iachini and Nobili (2014) systemic liquidity indicator for the Italian financial markets (red dashed line, right-hand scale).



Graph 7: Correlation between credit risk and liquidity risk indicators

Note: The graph depicts the 30-day rolling-window correlation (blue solid line) and the 90-day rolling-window correlation (red dashed line) between the credit risk indicator and the liquidity indicator.

the high levels of excess liquidity may have reduced the need to raise funds at the end of the maintenance period at high rates to fulfil the reserve requirements.

lated to the market include the maturity of the contract to account for the existence of potential term premia, and the total volume of contracts exchanged during the day.

The variables η_j are fixed effects to capture unobserved heterogeneity at liquidity provider level.

In theory, one may want to introduce fixed effects controlling for idiosyncratic features of each agent in the market. This would, in principle, imply an interaction in each contract of a dummy for the liquidity provider with a dummy for the liquidity taker. In practice, such an approach may work only in a market with very few agents; when the number of agents increases, the number of interactions grows at an exponential pace, thus leading to possible estimation biases. In addition, it is noted that exchanges are conducted anonymously, thus making the interaction less affected by the idiosyncratic features of market participants. We therefore opted for introducing fixed effects at the counterparty level. In particular, as explained in Section 3, since liquidity providers pay margins in CCP-cleared trades but do not sustain this cost in bilateral trades, we deem it more appropriate to set fixed effects at the liquidity provider level, since they may be more affected by the presence of margins. In any case, introducing fixed effects at the liquidity taker level, as shown in Section 6, does not significantly affect our results.

It is worth stressing that we consider only centrally cleared transactions; hence, bank-specific features are not included, given that, in effect, idiosyncratic counterparty risk is not a concern as trades are concluded anonymously. We acknowledge that bank-specific features, linked, for instance, to liquidity surplus or deficits corresponding to idiosyncratic conditions, may - in principle - affect the bidding behaviour adopted by banks on the trading platform. However, as shown in the following section, various experiments with fixed effects at the bank level indicate that, in practice, bank-specific features do not play a major role. Also, the use of low-frequency balance sheet data does not necessarily help to explain high-frequency data from the market. In any case, the use of fixed effects at the counterparty level should provide some reassurance that the specification adopted somehow controls for bank-specific features.

We first estimate a linear panel model with fixed effects and cluster-robust standard errors (ie adjusted for both serial correlation and heteroskedasticity). In a subsequent exercise, we run quantile panel regressions to explain the distribution corresponding to the 10th, 25th, 50th, 75th and 90th quantile, using all the explanatory variables as in the baseline regression. The purpose of this analysis is to better gauge how explanatory variables are related to the distribution of our spread measure.

6 Results

6.1 Baseline regressions

In this section, we illustrate the results obtained from the panel regressions described in Equation 11. In Table 4, we report the results of our baseline regressions by making use of OLS. We first perform a basic regression without considering margins and other variables, such as the total volumes exchanged in a day or the duration of the contract. We then extend the regression by introducing margins and additional controls. Over the period considered a 100 basis point increase in the level of initial margin translates into a significant and positive change in the ”repo rate-Eurepo spread” of about 3 or 4 basis points. As expected systemic risk indicators have a positive and significant effect on our dependent variable. In particular, the analysis suggests that the credit risk indicator has a predominant impact, as an increase of 100 basis points corresponds to about an 8 basis point increase in the cost of funding. In addition, the systemic liquidity indicator has a positive and significant impact. The impact of liquidity is also captured by a variable linked to the level of excess liquidity in the euro area with a negative sign; in particular, a liquidity injection of EUR 100 billion into the system reduces the cost of funding by about 3 basis points. The inclusion of variables capturing potential idiosyncratic pressures in liquidity needs (end-of-month, end-of-quarter and fiscal-due-date dummies) exerts, instead, a significant and upward impact on the cost of funding. The effect observed at the quarter-end is consistent with some anecdotal evidence collected on the markets.[29] Finally, we consider a number of variables directly related to the daily activity observed in the repo market. In particular, we find that a higher trading volume exchanged on the MTS repo market is associated with a lower funding cost faced by market participants on that market, thus suggesting the existence of a liquidity premium. In addition, the longer the maturity of the contract, the higher the spread observed, thus indicating the existence of a maturity premium attached to longer-term contracts concluded on the MTS repo market.

Overall, we find that the variables selected provide a good fit of the data, with the adjusted R-squared of about 59% in the richest specification, and most of the variables being significant at a level of 1%, with rather stable coefficients across specifications. Note that the inclusion of initial margins in the specification does not affect the sign and magnitude of the other coefficients, while it improves the explanatory power of the model (from an R-squared of 52% to one of 59%).

[29] For example, at the end of the first semester of 2013, the average overnight weighted rate dropped from 0.51% on the last day of the semester to 0.09% on the first day of July.

6.2 Robustness checks

In this section, we perform several robustness checks with respect to both the specification of the model and to the data sampling. The results found in the baseline regressions will overall be confirmed.

6.2.1 Endogeneity

To exclude the possibility that the findings are biased by potential endogeneity between the spread and the margin, we adopt a two-stage approach, where we first regress the margin on appropriate instruments and then replace the fitted value of the margin in the baseline regression. The concern is that the residuals of our baseline regression might not be orthogonal to mar_t and might therefore co-move with the margin in the case of shocks, leading to an overestimation of the impact of margins on the spread. More precisely, as instrumental variables we take the mean of mar_t across the previous 15 trading days and two measures of market uncertainty. These are a "time-series uncertainty", defined as the standard deviation of the average daily repo spread on a 15-day rolling-window, and a "cross-section uncertainty", given by the standard deviation of the difference between each contract spread and its daily average (15-day rolling window). In more rigorous terms, we construct the following measures:

$$\sigma_t^{TS} = \sum_{k=t-15}^{t-1} \sqrt{\left(\bar{s}_k - \bar{\bar{s}}_{t-1,t-15}\right)^2} \tag{12}$$

$$\sigma_t^{CS} = \frac{1}{15} \sum_{k=t-15}^{t-1} \sum_{l=1}^{n} \sqrt{\left(s_{l,k} - \bar{s}_k\right)^2} \tag{13}$$

$$\tag{14}$$

where $\bar{s}_t$ is the average spread in day t and $\bar{\bar{s}}_{t-1,t-15}$ is an average of $\bar{s}_t$ in the days from $t-15$ to $t-1$.

The results for IV regressions with different instrumental variables are reported on Table 5. The three columns report the results for 2SLS regressions, where the lag of mar_t (the first column) has only been used, or this variable along with the two uncertainty measures together (the second and third column). The results are very stable, both across regressions with different instrumental variables and compared with the baseline regression. This confirms the magnitude of the impact of initial margins on the cost of funding, and allows us to exclude that the results of the baseline regression are biased because of endogeneity issues.

6.2.2 Fixed effects

We then turn to discuss the role of fixed effects. In Table 6, we compare the outcome of the baseline regression with the ones obtained by introducing fixed effects at the liquidity taker level or by not introducing fixed effects at all. The results displayed in the table confirm the robustness of our approach. Introducing fixed effects at the level of the liquidity taker, or not introducing fixed effects at all, does not change significantly the coefficients estimated in the baseline specification, where, it is recalled, fixed effects are at the level of liquidity providers. This confirms the intuition that: (i) idiosyncratic counterparty risk is not a concern in anonymous, centrally cleared trades; and that (ii) bank-specific bidding behaviour does not impact trading on the platform.

6.2.3 Data subsamples

The previous findings are broadly confirmed also in further regressions on data subsamples. In particular, if we estimate regression (11) separately for short-term (one-day maturity) and long-term contracts (over one-day maturity), we can see that the sign and magnitude of the estimated coefficients are quite stable (Table 7). Although the dimension of longer-term contracts is smaller than that of short-term contracts, and therefore estimates might be - to a certain extent - less robust, some interesting features emerge. First, the impact of credit risk on the cost of funding is higher for longer-term contracts (10 basis points versus 8 basis points), suggesting that an increase in the level of credit risk had a greater effect on the cost of funding on longer maturities. This may be because agents entering into contracts on longer maturities are less affected by immediate liquidity needs and thus take other factors - such as credit risk - more into account.

Potential idiosyncratic pressures occurring on specific dates have, as expected, a higher impact on short-term maturity contracts, since such pressures have to be tackled by market participants before the end of the trading day. In the case of the Italian fiscal-due-dates, the change in the magnitude of the estimated coefficients is instead more moderate, possibly because only part of the sample, ie Italian counterparties only, is directly affected.

6.2.4 Data subperiods

The cost of funding exhibited an increasing pattern until the end of 2011 and, despite further increases in the CCPs' initial margins, it began declining from the beginning of 2012 (see Graph 2). We therefore investigate the stability of the relationship between initial margins and the cost of funding, splitting the sample into two sub-periods, with a break at the end of

2011. Such a choice is dictated by several arguments. First, Graph 2 shows that the most acute phase of the crisis in the Italian repo markets ended at the end of 2011. A significant change in the dynamics of this market can be observed between and after that date. In addition, in December 2011, a massive injection of liquidity by the ECB, in the form of the first Very Long-Term Refinancing Operation (VLTRO) took place, lifting excess liquidity in the system from EUR 290 billion to EUR 475 billion. Indeed, if we perform a structural break test on the excess liquidity time series, a break is identified between December 2011 and February 2012, exactly in conjunction with these non-conventional monetary policy operations. In the light of all these considerations we choose 21 December 2011 as the splitting date among subsamples. From the inspection of Table 8, it can be noted that in the first sub-period results are in line with the ones obtained in the full sample. In the second sub-period, instead, margins seem to lose significance in determining the cost of funding (see column 3 of Table 8). However, if we include in $X_{i,t}^{repos}$ as explanatory variables both the excess liquidity for the euro area and its squared value, the magnitude and the relevance of initial margins' impact on the cost of funding becomes, once again, consistent with the results of the baseline regression (see column 4 of Table 8). An explanation of this finding is possibly related to the existence of a non-linear, although positive, relationship between liquidity and the cost of funding. The execution of the VLTRO has possibly altered the dynamics observed in the crisis period, but these effects may, somehow, lose significance in the full sample.

6.3 The impact of margins on quantities

We also run the baseline regression (11) considering quantity as our dependent variable instead of the cost of funding. This allows us to check whether margins - as predicted in the theoretical model - also impact quantities traded in each exchange on the market (see Table 9).[30] The effect of initial margins on the quantity exchanged in the single contract is negative, thus confirming the finding in the theoretical model. In particular, a 100 basis-point increase in initial margins converts into a 0.64 million euro decrease in the volume traded in average contracts. As expected, excess liquidity provided by the Eurosystem contributes reducing turnover in private markets. This finding is robust also to a 2SLS regression where we use the lag of mar_t and the "cross-section" and "time-series" volatilities as instruments. Compared with cost of funding regressions, the ones on quantities fit poorly (R^2 of about 2 %).

[30] The only difference with the baseline regression - apart from the left-hand side variable - is the exclusion of the total volume of contracts exchanged during the day as a control variable.

6.4 Quantile regressions

The distribution in the cost of funding is characterised by a significant dispersion. Therefore, using our baseline framework as in Equation 11, we run quantile panel regressions on the 10th, 25th, 50th, 75th and 90th quantile. Also in this case, standard errors are robust and corrected for heteroskedasticity. In this way, we are able to estimate the potential differential effect of our covariates on the quantiles of the conditional distribution of our dependent variable, thus providing richer data characterisation.

The regression coefficients, estimated over the whole sample period, are shown in Table 10. The results confirm that the impact of initial margins on the cost of funding remains significant and positive across the distribution. Interestingly, the magnitude of the effect increases at the highest conditional quantiles of the distribution: a 100 basis-point increase in the initial margin translates into a significant and positive change in the cost of funding, in the range of 2 basis points up to the median and then picking up significantly (up to 4 basis points) in the upper tail of the distribution. Credit and liquidity risk are significantly and positively related to the cost of funding for all the quantiles and relatively more for the upper tail. Indeed, the impact of credit risk is much larger in the case of contracts belonging to the upper tail of the distribution: the estimated coefficient increases by about seven times from the 10th to the 90th quantile. Looking at the impact of the ECB interventions, it can be seen that the amount of excess liquidity in the system helps to ease the pressure on the cost of funding, with a larger estimated impact (in absolute terms) for higher quantiles. This effect is particularly pronounced for the 90th quantile - the coefficient being almost three times larger than the one for the median quantile. The coefficients for the other explanatory variables are in line with our expectations, as well as in the estimation obtained in the baseline specification. Overall, these results point to the fact that in the upper tail of the distribution, namely for those contracts whose rate far exceeds the Eurepo rate, the cost of funding is more responsive to changes in initial margins and risk factors. We believe that the upper tail of the distribution is populated primarily by counterparties that are liquidity-constrained at that specific moment and are willing to conclude repos at higher rates to obtain funds. Our intuition is that, when aggregate liquidity is lower and risks are higher, liquidity-constrained counterparties pay higher funding costs to obtain secured credit. In a similar vein, higher initial margins make secured credit relatively more expensive, with adverse funding consequences especially for liquidity-constrained banks.

6.5 A counterfactual exercise

The relevance of the above figures can be further assessed in the following counterfactual exercise, where we quantify the contribution of initial margins to the increase in repo spreads occurred during the financial turmoil. More precisely, we use the estimated coefficients from the richest regression in Table 4 and the regression on the median in Table 10, the residuals and the time series of the independent variables to calculate the spread that would have been realised if margins were kept at the pre-crisis level. In other words, we compute a counterfactual spread as:

$$\widehat{s}_{i,t} = \widehat{\alpha} + \widehat{\beta}_1 \overline{mar}_t + \widehat{\beta}_2 X_{t-1}^{mkt} + \widehat{\beta}_3 X_t^{repos} + \widehat{\varepsilon}_{i,t} \tag{15}$$

Where $\overline{mar}_t$ is the average pre-crisis level of weighted margin.[31]

The results are reported in Table 11. The average spread observed in the data has been 12 basis points. If the margin had remained fixed at the pre-crisis level, the average spread in the sample would have been 1.5 basis points (using OLS estimates) or 5.8 basis points (using QR on the median). This translates into a reduction of, respectively, 88% and 52% compared with the average spread observed in the data. In other words, in a scenario of pre-crisis margins, the spread between the repo rates on the Italian MTS and the Eurepo rate would have been much lower than the value effectively observed on the markets. From this simple exercise, it could be argued that a non-negligible part of the funding cost can be explained by changes in margin policies.

7 Conclusions

In this paper, we investigated the impact of CCPs' initial margin policies on the cost of funding, showing the existence of a theoretical positive relationship between these two variables which is confirmed by empirical evidence. Drawing on an extensive transaction-level data set on the Italian MTS Repo market (the GC segment) available at the Bank of Italy for supervisory purposes for the period 2011-2014, we find that initial margins, paid by all participants, have significantly and positively affected the cost of funding observed on GC MTS Repo Italy; on average, the impact is equal to about 3 basis points for each 1 percentage point variation in the margin. Among the other variables playing a role, we find that credit and liquidity risks, as well as variables capturing potential idiosyncratic pressures in liquidity needs (end-of-month, end-of-quarter and fiscal-due-date dummies), exert a significant and upward

[31] This value (3.3%) has been computed as an average over the period January-July 2011.

impact on the cost of funding. Variables linked to the level of excess liquidity in the euro area have instead a negative effect. This paper thus represents a first attempt at identifying causal relationships in CCP-cleared repo markets in times of stress. Future research may be devoted to identifying whether different drivers of the cost of funding in non-centrally-cleared repo markets exist, and to empirically quantifying the relevance of self-fulfilling (”procyclical”) dynamics.

References

Abruzzo, N. and Y.-H. Park (2014): "An empirical analysis of futures margin changes: determinants and policy implications," .

Acharya, V. and A. Bisin (2014): "Counterparty risk externality: Centralized versus over-the-counter markets," *Journal of Economic Theory*, 149, 153–182.

Acharya, V. V., D. Gale, and T. Yorulmazer (2011): "Rollover Risk and Market Freezes," *Journal of Finance*, 66, 1177–1209.

Acharya, V. V. and T. S. Öncü (2012): "A proposal for the resolution of systemically important assets and liabilities: The case of the repo market," CEPR Discussion Papers 8927, C.E.P.R. Discussion Papers.

Bank of Italy (2014a): "Financial Stability Report, n. 1, May 2014," .

——— (2014b): "Financial Stability Report, n. 2, November 2014," .

Biais, B., F. Heider, and M. Hoerova (2012): "Clearing, Counterparty Risk, and Aggregate Risk," *IMF Economic Review*, 60, 193–222.

Boissel, C., F. Derrien, E. Örs, and D. Thesmar (2014): "Sovereign Crises and Bank Financing: Evidence from the European Repo Market," .

Bolton, P., T. Santos, and J. A. Scheinkman (2009): "Market and Public Liquidity," *American Economic Review*, 99, 594–99.

Brumm, J., M. Grill, F. Kubler, and K. H. Schmedders (2013): "Collateral requirements and asset prices," *Swiss Finance Institute Research Paper*.

Brunnermeier, M. K. and L. H. Pedersen (2009): "Market liquidity and funding liquidity," *Review of Financial studies*, 22, 2201–2238.

Buraschi, A. and D. Menini (2002): "Liquidity risk and specialness," *Journal of Financial Economics*, 64, 243–284.

CGFS (2010): "The role of margin requirements and haircuts in procyclicality," Tech. Rep. CGFS Papers No 36.

Coeuré, B. (2014): "The known unknowns of central clearing," Speech at the meeting on global economy and financial system hosted by the University of Chicago Booth School of Business Initiative on Global Markets at Coral Gables, Florida.

Copeland, A., I. Davis, E. LeSueur, and A. Martin (2012): "Mapping and Sizing the U.S. Repo Market," .

CPSS (2010): "Strengthening repo clearing and settlement arrangements," Tech. rep.

CPSS-IOSCO (2012): "Principles for Financial Market Infrastructures," Tech. rep.

Duffie, D. (1996): "Special repo rates," *The Journal of Finance*, 51, 493–526.

ECB (2012): "Shadow Banking in the euro-area. An overview," Tech. rep.

——— (2014a): "Euro Money Market Survey," .

——— (2014b): "Recent Developments in Excess Liquidity and Money Market Rates," *ECB Monthly Bulletin*, 69–82.

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

FSB (2012): "Securities Lending and Repo: Market Overview and Financial Stability Issues," Tech. rep.

——— (2013): "Policy Framework for Addressing Shadow Banking Risks in Securities Lending and Repos," Tech. rep.

——— (2014): "Regulatory framework for haircuts on non-centrally cleared securities financing transactions," Tech. rep.

Gai, P., A. Haldane, and S. Kapadia (2011): "Complexity, concentration and contagion," *Journal of Monetary Economics*, 58, 453–470.

Gârleanu, N. and L. H. Pedersen (2011): "Margin-based Asset Pricing and Deviations from the Law of One Price," *Review of Financial Studies*, 24, 1980–2022.

Gilchrist, S. and B. Mojon (2014): "Credit Risk in the Euro area," .

Goodhart, C. A., A. K. Kashyap, D. P. Tsomocos, and A. P. Vardoulakis (2012): "Financial regulation in general equilibrium," Tech. rep., National Bureau of Economic Research.

Gorton, G. and A. Metrick (2012): "Securitized banking and the run on repo," *Journal of Financial Economics*, 104, 425–451.

Iachini, E. and S. Nobili (2014): "An indicator of systemic liquidity risk in the Italian financial markets," Questioni di Economia e Finanza (Occasional Papers) 217, Bank of Italy, Economic Research and International Relations Area.

ICMA (2014): "European repo market survey," Tech. rep.

——— (2015): "European repo market survey," Tech. rep.

IMF (2010): "Making Over-the-Counter Derivatives Safer: The Role of Central Counterparties," *Global Financial Stability Report*.

Jordan, B. D. and S. D. Jordan (1997): " Special Repo Rates: An Empirical Analysis," *Journal of Finance*, 52, 2051–72.

Koeppl, T., C. Monnet, and T. Temzelides (2012): "Optimal clearing arrangements for financial trades," *Journal of Financial Economics*, 103, 189–203.

Krishnamurthy, A., S. Nagel, and D. Orlov (2014): "Sizing up repo," *The Journal of Finance*.

Mancini, L., A. Ranaldo, and J. Wrampelmeyer (2014): "The Euro Interbank Repo Market," Tech. rep.

Rytchkov, O. (2014): "Asset pricing with dynamic margin constraints," *The Journal of Finance*, 69, 405–452.

Singh, M. (2010): "Collateral, Netting and Systemic Risk in the OTC Derivatives Market," IMF Working Papers 10/99, International Monetary Fund.

Stein, J. C. (2012): "Monetary Policy as Financial Stability Regulation," *The Quarterly Journal of Economics*.

Taylor, J. B. and J. C. Williams (2009): "A black swan in the money market," *American Economic Journal: Macroeconomics*, 1.

Valderrama, L. (2015): "Macroprudential regulation under repo funding," *Journal of Financial Intermediation*, 24, 178–199.

8 Tables

Table 1: Sample Description

	Total sample		CC&G		LCH		Interoperability	
	N. contracts	% of total	N. contracts	% of total	N. contracts	% of total	N. contracts	% of total
Total in the sample	531168	100						
of which CCP-cleared:	476086	0.8963002	125400	0.2360835	71916	0.1353922	278770	0.5248245
	Maturity buckets							
ON	124436	26.1%	26341	21.0%	22768	31.7%	75327	27.0%
TN	159229	33.4%	39201	31.3%	27220	37.8%	92808	33.3%
SN	165738	34.8%	46657	37.2%	20659	28.7%	98422	35.3%
1W	9655	2.0%	5814	4.6%	383	0.5%	3458	1.2%
2W	4405	0.9%	3329	2.7%	81	0.1%	995	0.4%
1M	4899	1.0%	1459	1.2%	384	0.5%	3056	1.1%
2M	550	0.1%	135	0.1%	23	0.0%	392	0.1%
3M	1072	0.2%	273	0.2%	99	0.1%	700	0.3%
6M	221	0.0%	85	0.1%	9	0.0%	127	0.0%
9M	8	0.0%	5	0.0%	1	0.0%	2	0.0%
1Y	133	0.0%	67	0.1%	7	0.0%	59	0.0%
BD	5740	1.2%	2034	1.6%	282	0.4%	3424	1.2%
Total	476086		125400		71916		278770	

Table 2: Descriptive statistics

Variable	Mean	Std Dev	Min	Max
Spread (b.p.)	12.03	17.32	-57.30	283.70
Margin (b.p.)	635.46	155.46	291.04	871.61
Credit risk (b.p.)	454.68	118.76	241.52	987.16
Liquidity risk (b.p.)	2531.43	2252.34	98.27	9073.77
Total Liquidity (bln euro)	351.69	260.94	-93.94	811.86
Total volume (mln euro)	27.98	6.61	10.36	49.72

Note: descriptive statistics are computed on a sample of 466072 observations. ”Spread” is computed as the daily mean of the spread as computed in eq. (10). ”Margin” is the daily average level of margins weighted by the outstanding government debt amount for each bucket of duration. ”Credit risk” is the credit spread measure of (Gilchrist and Mojon, 2014) for the Italian banking sector. ”Liquidity risk” is the liquidity indicator of (Iachini and Nobili, 2014). ”Total liquidity” is excess liquidity for the euro area, computed as the sum of the deposit facility net of the recourse to the marginal lending facility, plus current account holdings in excess of those contributing to the minimum reserve requirements. ”Total volume” is the daily volume of GC repo transactions executed on the MTS Repo Italy trading platform.

Table 3: Correlation among credit and liquidity risk variables

	Liquidity	Credit risk	BTP-Bund spread	VIX	BTP volatility
Liquidity	1				
Credit risk	0.8412*	1			
BTP-Bund spread	0.6946*	0.7433*	1		
VIX	0.7014*	0.6622*	0.3548*	1	
BTP volatility	0.6595*	0.6338*	0.5833*	0.4501*	1

Note: correlations computed on 466072 observations. (*): significance level at 1%.

Table 4: Baseline Regressions

Margin		**0.0364*****	**0.0354*****
		(0.00313)	*(0.00286)*
Credit Risk	**0.0702*****	**0.0785*****	**0.0794*****
	(0.00821)	*(0.00643)*	*(0.00637)*
Liquidity Risk	**0.00185*****	**0.00207*****	**0.00170*****
	(0.000126)	*(0.000139)*	*(0.000129)*
Total Liquidity	**-0.0171*****	**-0.0282*****	**-0.0285*****
	(0.00143)	*(0.00236)*	*(0.00237)*
Fiscal Due Dates	**1.926*****	**1.719*****	**1.861*****
	(0.273)	*(0.183)*	*(0.190)*
Dummy Month	**6.866*****	**6.476*****	**6.304*****
	(0.626)	*(0.591)*	*(0.550)*
Dummy Quarter	**34.57*****	**35.88*****	**35.83*****
	(3.328)	*(2.979)*	*(2.935)*
Total Volume			**-0.176*****
			(0.0222)
Maturity			**0.106*****
			(0.00888)
Constant	**-19.57*****	**-43.12*****	**-37.19*****
	(3.401)	*(4.248)*	*(3.468)*
Observations	464652	464652	464652
R-squared	***0.524***	***0.577***	***0.582***

Note: "Fiscal Due Dates" is a dummy that takes value one on Italian fiscal due dates and zero otherwise. "Dummy Month" and "Dummy Quarter" take value one in the last day of the month and of the quarter, respectively, and zero otherwise. "Maturity" is the maturity of the contract in number of days. Standard errors are reported in parenthesis and are clustered at the liquidity provider level.

Table 5: Robustness checks with instrumental variables

	(IV= Lag margin)	(IV= Lag Margin and cross-section vola.)	(IV= Lagged Margin, cross-section and time series vola.)
Margin	**0.0362*** **	**0.0359*** **	**0.0345*** **
	(0.00312)	(0.00313)	(0.00322)
Credit Risk	**0.0846*** **	**0.0845*** **	**0.0839*** **
	(0.00669)	(0.00671)	(0.00680)
Liquidity Risk	**0.00170*** **	**0.00170*** **	**0.00169*** **
	(0.000113)	(0.000113)	(0.000112)
Total Liquidity	**-0.0291*** **	**-0.0290*** **	**-0.0285*** **
	(0.00225)	(0.00225)	(0.00226)
Fiscal Due Dates	**1.991*** **	**1.994*** **	**2.007*** **
	(0.203)	(0.203)	(0.204)
Dummy Month	**6.444*** **	**6.446*** **	**6.453*** **
	(0.549)	(0.548)	(0.547)
Dummy Quarter	**36.08*** **	**36.06*** **	**36.00*** **
	(2.914)	(2.917)	(2.931)
Total Volume	**-0.145*** **	**-0.146*** **	**-0.151*** **
	(0.0190)	(0.0191)	(0.0194)
Maturity	**0.118*** **	**0.118*** **	**0.118*** **
	(0.0101)	(0.0101)	(0.0100)
Constant	**-40.84*** **	**-40.56*** **	**-39.44*** **
	(3.649)	(3.657)	(3.734)
Observations	460025	460025	460025
R-squared	***0.575***	***0.575***	***0.575***

Note: Standard errors are reported in parenthesis and are clustered at the liquidity provider level.

Table 6: Robustness checks with different fixed effects specifications

	No fixed effects	FE on liquidity provider	FE on liquidity taker
Margin	**0.0346***** (0.00319)	**0.0354***** *(0.00286)*	**0.0343***** *(0.00249)*
Credit Risk	**0.0820***** *(0.00672)*	**0.0794***** *(0.00637)*	**0.0781***** *(0.00494)*
Liquidity Risk	**0.00168***** *(0.000111)*	**0.00170***** *(0.000129)*	**0.00168***** *(9.43e-05)*
Total Liquidity	**-0.0287***** *(0.00227)*	**-0.0285***** *(0.00237)*	**-0.0276***** *(0.00172)*
Fiscal Due Dates	**1.928***** *(0.211)*	**1.861***** *(0.190)*	**1.771***** *(0.181)*
Dummy Month	**6.326***** *(0.537)*	**6.304***** *(0.550)*	**6.177***** *(0.534)*
Dummy Quarter	**36.00***** *(2.921)*	**35.83***** *(2.935)*	**35.95***** *(2.411)*
Total Volume	**-0.178***** *(0.0202)*	**-0.176***** *(0.0222)*	**-0.166***** *(0.0136)*
Maturity	**0.116***** *(0.0100)*	**0.106***** *(0.00888)*	**0.0939***** *(0.0109)*
Constant	**-37.72***** *(3.560)*	**-37.19***** *(3.468)*	**-36.37***** *(3.011)*
Observations	464652	464652	464652
R-squared	***0.572***	***0.582***	***0.588***

Note: Standard errors are reported in parenthesis and are clustered at the liquidity provider level in the first two columns, while they are clustered at the liquidity taker level in the third column.

Table 7: 1 day contracts vs longer maturities contracts

	1 day	>1day
Margin	**0.0354*** **	**0.0341*** **
	(0.00303)	*(0.00271)*
Credit Risk	**0.0780*** **	**0.0972*** **
	(0.00642)	*(0.00897)*
Liquidity Risk	**0.00168*** **	**0.00222*** **
	(0.000136)	*(0.000323)*
Total Liquidity	**-0.0282*** **	**-0.0294*** **
	(0.00245)	*(0.00215)*
Fiscal Due Dates	**1.798*** **	**1.566** **
	(0.188)	*(0.737)*
Dummy Month	**6.442*** **	**3.175** **
	(0.561)	*(1.530)*
Dummy Quarter	**37.14*** **	**9.833*** **
	(3.229)	*(2.766)*
Total Volume	**-0.185*** **	-0.0258
	(0.0243)	*(0.0431)*
Constant	**-36.36*** **	**-43.42*** **
	(3.518)	*(4.603)*
Observations	443989	20663
R-squared	***0.579***	***0.661***

Note: Standard errors are reported in parenthesis and are clustered at the liquidity provider level.

Table 8: Regressions on Subperiods

Subsamples	3rd Jan 2011-21st Dec 2011		22nd Dec 2011-16th Apr 2014		Full Sample
Margin	**0.0327*** **	**0.0320*** **	**0.00687**	**0.0336*** **	**0.0436*** **
	(0.00675)	*(0.00738)*	*(0.00477)*	*(0.00366)*	*(0.00223)*
Credit Risk	**0.0785*** **	**0.0475*** **	**0.00758** **	**0.0143*** **	**0.0795*** **
	(0.0106)	*(0.00957)*	*(0.00364)*	*(0.00311)*	*(0.00595)*
Liquidity Risk	**0.00107*** **	**0.00157*** **	**0.00213*** **	**0.00244*** **	**0.00189*** **
	(0.000257)	*(0.000228)*	*(9.37e-05)*	*(0.000106)*	*(0.000120)*
Total Liquidity	**0.0306*** **	**-0.0280***	**-0.00575*** **	**-0.0512*** **	**-0.0530*** **
	(0.00575)	*(0.0145)*	*(0.000733)*	*(0.00342)*	*(0.00430)*
(Total Liquidity)^2		**0.000331*** **		**4.71e-05*** **	**2.65e-05*** **
		(9.61e-05)		*(3.18e-06)*	*(5.79e-06)*
Fiscal Due Dates	**4.961*** **	**4.968*** **	**0.436*** **	**0.421*** **	**1.916*** **
	(0.749)	*(0.723)*	*(0.144)*	*(0.152)*	*(0.189)*
Dummy Month	**8.600*** **	**8.482*** **	**6.389*** **	**6.632*** **	**6.387*** **
	(1.052)	*(1.053)*	*(0.566)*	*(0.545)*	*(0.535)*
Dummy Quarter	**24.44*** **	**25.11*** **	**40.36*** **	**39.88*** **	**35.68*** **
	(3.603)	*(3.590)*	*(3.532)*	*(3.582)*	*(2.962)*
Total Volume	**-0.332*** **	**-0.383*** **	**-0.00109**	**0.0561*** **	**-0.149*** **
	(0.0348)	*(0.0393)*	*(0.0113)*	*(0.0123)*	*(0.0298)*
Maturity	**0.148*** **	**0.138*** **	**0.0952*** **	**0.0953*** **	**0.107*** **
	(0.0171)	*(0.0177)*	*(0.00940)*	*(0.00888)*	*(0.00860)*
Constant	**-32.38*** **	**-16.35*** **	-2.484	**-18.55*** **	**-40.18*** **
	(4.206)	*(5.927)*	*(2.660)*	*(2.025)*	*(2.826)*
Observations	117055	117055	347597	347597	464652
R-squared	***0.669***	***0.678***	***0.472***	***0.494***	***0.585***

Note: Standard errors are reported in parenthesis and are clustered at the liquidity provider level.

Table 9: Regression on contract volumes

	OLS	2SLS
Margin	**-0.00647****	**-0.0126*****
	(0.00288)	*(0.00390)*
Credit Risk	-0.00430	0.00210
	(0.00447)	*(0.00437)*
Liquidity Risk	**-0.000822*****	**-0.00108*****
	(0.000224)	*(0.000228)*
Total Liquidity	**-0.00349*****	**-0.00231***
	(0.00126)	*(0.00122)*
Fiscal Due Dates	0.0497	0.209
	(0.386)	*(0.446)*
Dummy Month	-0.423	-0.321
	(0.802)	*(0.858)*
Dummy Quarter	1.169	0.685
	(1.447)	*(1.463)*
Maturity	**0.190*****	**0.221*****
	(0.0548)	*(0.0635)*
Constant	**51.22*****	**52.36*****
	(1.636)	*(1.932)*
Observations	460025	460025
R-squared	***0.019***	***0.005***

Note: Standard errors are reported in parenthesis and are clustered at the liquidity provider level. Instruments in the 2SLS regression are the lagged margin and cross-section and time series volatilities, as defined in the text.

Table 10: Quantile regressions

Quantile	10th	25th	50th	75th	90th
Margin	**0.0194*****	**0.0179*****	**0.0203*****	**0.0324*****	**0.0401*****
	(0.00101)	(0.00241)	(0.00422)	(0.00368)	(0.00447)
Credit Risk	**0.0157*****	**0.0322*****	**0.0512*****	**0.0800*****	**0.106*****
	(0.00522)	(0.0102)	(0.0108)	(0.00638)	(0.00409)
Liquidity Risk	**0.00169*****	**0.00159*****	**0.00204*****	**0.00228*****	**0.00287*****
	(0.000127)	(0.000146)	(0.000149)	(0.000139)	(0.000176)
Total liquidity	**-0.00191****	**-0.00836*****	**-0.0172*****	**-0.0305*****	**-0.0449*****
	(0.000793)	(0.00163)	(0.00264)	(0.00247)	(0.00177)
Fiscal due dates	**0.703*****	**0.610*****	**0.910*****	**0.697****	**0.684****
	(0.0806)	(0.163)	(0.204)	(0.330)	(0.325)
Dummy month	**2.404*****	**3.339*****	**4.040*****	**6.360*****	**8.057*****
	(0.350)	(0.515)	(0.745)	(0.690)	(0.531)
Dummy quarter	**10.96*****	**18.69*****	**31.15*****	**44.68*****	**66.38*****
	(0.741)	(1.394)	(0.999)	(3.354)	(3.548)
Total volume	-0.0267	**-0.0693*****	**-0.139*****	**-0.164*****	**-0.102*****
	(0.0179)	(0.0152)	(0.0272)	(0.0440)	(0.0333)
Maturity	**0.0862*****	**0.109*****	**0.142*****	**0.158*****	**0.176*****
	(0.00472)	(0.00760)	(0.0140)	(0.0139)	(0.0220)
Constant	**-20.44*****	**-20.16*****	**-21.95*****	**-32.32*****	**-40.14*****
	(1.606)	(4.603)	(5.357)	(3.145)	(3.161)
Obs	*464652*				
R-squared	***0.411***	***0.533***	***0.560***	***0.568***	***0.557***

Note: Standard errors are reported in parenthesis and are clustered at the liquidity provider level.

Table 11: Conterfactual exercise

Mean Spread (data)	12.1	
	Quantile	**OLS**
Counterfactual	5.8	1.5

Previous volumes in this series

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