ISSN 0956-8549

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DISCUSSION PAPER NO 910

June 2024

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September 21, 2023

Abstract

Using a unique transaction-level data, we document that only 60% of bilateral repos held by UK banks are backed by high quality collateral. Banks intermediate repo liquidity among different counterparties and use CCPs to reallocate high-quality collaterals among themselves. Furthermore, maturity, collateral rating and asset liquidity have important effects on repo liquidity via haircuts. Counterparty types also matter: non-hedge funds, large borrowers, and borrowers with repeated bilateral relationships receive lower (or zero) haircuts. The evidence supports the adverse selection model of haircuts that we provide, and we do not find significant roles in the data for mechanisms related to lenders' liquidity position or default probabilities.

Keywords: repurchase agreement, systemic risk, repo market, margin, haircut.
JEL codes: G12, G21, G23, E43, E58.

*We would like to thank Evangelos Benos, Sinem Hacioglu, Neeltje van Horen, Elias Papaioannou, John Power, Angelo Ranaldo, Andreas Schrimpf, Nick Vause, conference participants at the LSE, the 2017 London Financial Intermediation Workshop at the Bank of England, the European Meeting of the Econometric Society 2019, and the RiskLab/BoF/ESRB Conference on Systemic Risk Analytics 2019.

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1 Introduction

The repurchase agreement (repo) market is a major tool for short-term funding of financial institutions, potentially an important source of systemic risks in the financial system.[1] There is ample interest from academics, policy makers and members of the public in better understanding and monitoring this market. However, due to the over-the-counter nature of repo transactions, repo contract terms are rarely disclosed except for tri-party repo financed by US Treasury securities. Limited studies on bilateral repo transactions have shown that bilateral repo markets are significantly different from tri-party repo markets in terms of collaterals and counterparties. However, due to various data restrictions, evidence on how collateral and counterparty characteristics affect contract terms is often suggestive and limited.[2] Furthermore, even though the repo market in the EU and the UK are much larger than that in the US, our understanding of the determination of repo contract terms is almost exclusively based on US databases.[3] As a result, we still know relatively little about patterns of deal characteristics in bilateral repo market or the market-wide cross-sectional relationships between haircuts, collaterals and counterparty characteristics, especially about the EU and UK repo markets.

Our paper fills this gap in the literature by establishing a novel understandings of the makeup of the bilateral markets, and estimating the cross-sectional relationships of contract terms and deal characteristics. We investigate a unique transaction-level UK dataset that has a cross-section of borrowers and lenders and, importantly, by showing which *market frictions* (e.g., adverse selection) are relevant for repo haircuts in general. To our knowledge, this is the only database that covers transaction-level haircut information for collaterals with a wide range of qualities and a rich set of counterparty characteristics.

[1]During the financial crisis in 2008 repo markets experienced various disruptions and potentially contributed to the severity of the crisis. For example Copeland et al. (2010) show that, during the days prior to Lehman Brothers' bankruptcy, the amount of collateral financed by the bank in tri-party repo fell drastically. Gorton and Metrick (2012) argue that the repo market experienced a run during that episode, manifested in a rise of haircuts, which exacerbated the crisis.

[2]For example, Gorton and Metrick (2012) focus on the impact of collateral rating/asset class on repo terms since their database does not contain counter-party information. The analysis in Auh and Landoni (2022) is limited to a single borrower since the data is collected from one hedge fund family. Baklanova et al. (2019) find the effect of collateral price volatility on repo haircut mixed and inconclusive using three time snaps of repo data from nine US bank holding companies.

[3]The total value of all outstanding repos reported under the Securities Financing Transactions Regulations (SFTR) in the EU and the UK on December 10, 2021 was EUR 9,396 billion in the EU and EUR 8,448 billion in the UK, totalling EUR 17.8 trillion (https://www.icmagroup.org/assets/European-Repo-Market-Survey-April-2022.pdf). The Federal Reserve estimates the total repo assets (or investments in repos) in the US at around $4.6 trillion as of September 30, 2020 (https://www.sec.gov/files/mmfs-and-the-repo-market-021721.pdf).

It also provides an opportunity to analyse an understudied major repo market segment. The dataset allows us to gain a market-wide view on how UK banks use bilateral repo contracts to intermediate liquidity across different counterparties and to study how the supply of this liquidity is affected by collateral quality, counterparty characteristics, bilateral relationships, and contract terms.

Our bird's-eye investigation reveals four distinct features about the UK bilateral repo market. First, we find that only 60% of collaterals used in the UK market can be categorized as high quality cash-like securities: we label such repo contracts "cash repo". 7% of collaterals are classified as credit securities, which we label "credit repo", and the other 33% of the collaterals are of medium quality.[4] In contrast, the existing studies using tri-party repo data in the US market find that high quality securities such as US Treasuries are predominately used as collaterals (e.g., Copeland et al. (2010), Baklanova et al. (2019)).[5] The cross-sectional variation in the qualities of collateral used in the bilateral repo transactions leads to significant heterogeneity in haircuts among repo contracts in the UK market.

Second, we find a clear pattern on how banks intermediate liquidity among each other using central clearing counterparties (CCPs), and from asset managers to hedge funds via the UK bilateral repo market. Banks obtain liquidity from asset managers, while providing liquidity to hedge funds. In doing so, banks also earn intermediating spreads as they charge higher haircuts to their (net) borrowers – hedge funds – and are charged less by their (net) lenders – asset managers. For example, the banks charge intermediation spreads in terms of haircut as high as 1.3% to hedge funds and as low as 30 bps to broker dealers.[6] We also find that CCP trades are significantly different from non-CCP trades: banks tend to use high quality collaterals and to trade in large notional values when trans-

[4]In our sample, in determining the quality of individual bonds, we draw on conventions from the academic literature rather than those of any individual central bank. Specifically, we refer to government bonds from the UK, the US, Germany, France, Japan, France, Belgium, the Netherlands or Austria as cash instruments since their ratings were above AA during the sample period. We follow the convention of the academic literature in defining corporate bonds and securitized products as credit instruments. The rest of the collateral sample is classified as medium quality.

[5]The EU and UK repo markets have a larger share of lower-quality securities than the US market for several reasons. First, the supply of the high quality of government bonds is relatively low. For example, Germany is one of the main suppliers for safe assets in the EU area. The government debt to GDP ratio is much lower for Germany than the US, implying that the supply of the safest asset is relatively limited. Second, ECB accepts EU area government bonds of lower quality in their repo operations, albeit with higher haircuts. Hence, banks might have incentive to hold low quality government bonds which offer access to central bank liquidity.

[6]We do not find that our reporting banks intermediate funds when trading with central banks and government agencies, insurance companies and pension funds, and other reporting banks. In fact, they often pay higher haircuts when borrowing from these counterparties.

acting with CCPs. These patterns indicate the important role of CCPs for banks when reallocating high quality collaterals among themselves.

Third, we find evidence for collateral rehypothecation – on average, about 30% of collaterals are rehypothecated and this fraction is higher for cash than for credit collaterals. Fourth, we find that a significant portion of bilateral contracts have zero haircut: 35% of all transactions.

After revealing these unique characteristics of the UK repo market in allocating liquidity, we turn to investigate the drivers behind the cross-sectional heterogeneity in haircuts, including the probability of receiving a zero haircut. In particular, we build six testable hypotheses based on a stylized model with information friction as well as the existing theoretical work on collateralized borrowing and repo runs.[7] Our six hypotheses can be broadly categorised into three groups: collaterals', borrowers', and lenders' characteristics. Characteristics include typical quality variables such as default probability and credit rating but also liquidity indicators, concentration risks, counterparty types and some other variables. Existing theoretical models based on various market frictions have different predictions on how these characters affect haircuts.

To test our six hypotheses, in our empirical investigation, we group the potential explanatory variables into five categories: deal, collateral, counterparty type, counterparty characteristics, and miscellaneous factors including concentration measures. We then examine their impact on the magnitude of haircuts and the probability of zero haircuts (given the large number of contracts with zero haircut in the data). In the main analysis of the paper, we focus on the non-CCP subsample because the institutional setups are different when repo trades are cleared via CCPs. The reported haircuts by borrowers tend to be lower because they establish separate margin accounts with CCPs. Our regression analysis exploits heterogeneity in collateral and counterparty characteristics, yielding four main results.

First, we find that transaction maturity – a deal characteristic – has a first order effect: haircuts are larger for longer maturities of the contract. Haircuts are also increasing in

[7] The theoretical literature in these areas can be categorized into two main streams. One is based on the difference of opinion approach in a general equilibrium setting (e.g., Geanakoplos (1997) and Simsek (2013)). The other is based on contractual and/or information frictions (e.g., Dang et al. (2013), Dang et al. (2011), Ozdenoren et al. (2018) and Gottardi et al. (2019)).These theoretical models have been applied to explain repo runs which were prevalent during the financial crisis in 2008. The existing theories point out two types of repo runs: one is liquidity runs, which focus on coordinations by extending Diamond and Dybvig (1983) either to the repo setting (Martin et al. (2014)), short-term borrowing (Acharya et al. (2011)), or endogenous information acquisition (Gorton and Ordonez (2014)); the other is inter-temporal coordination runs based on an adverse selection mechanism (Ozdenoren et al. (2018)).

the Value at Risk (VaR) of the collateral and in collateral concentration, but decreasing in collateral rating. Haircuts are also generally lower for portfolios that include a safe asset. This set of findings indicates that collateral quality and asset liquidity are important determinants of haircuts.

Second, we find that counterparties matter in haircut determination. This finding is especially useful as it allows to untangle various economic mechanisms that affect banks' intermediation of liquidity via repos. We find that hedge funds are charged significantly higher haircuts, especially when using credit collateral: the haircut increases by staggering 28% when hedge funds borrow using such collateral. Moreover, larger borrowers with higher ratings receive lower haircuts, which shows that there is significant tiering in the repo market. We also find that borrower-lender relationships affect haircuts significantly: some borrowers receive consistently lower haircuts when interacting with certain counterparties, and one–two banks in our sample account for the bulk of repo trades with zero haircuts. These findings are hard to explain by the difference of opinion theory since the significant borrower-lender relationships are often for agents from different lines of business. The results are, however, supportive of the adverse selection theory since relationship banking lowers information frictions.[8]

Third, we find little evidence that lenders' liquidity position or default probabilities affect haircuts, suggesting that the traditional bank run mechanism cannot explain repo runs. This lends support to the alternative inter-temporal feedback/coordination explanations of repo runs instead.

Fourth, when examining the likelihood of receiving zero haircuts, we find that, in addition to the determinants mentioned above, bilateral relationships explain large part of the variation in the probability of receiving a zero haircut. This finding indicates that banks filter out repo clients in conducting repo business and give preferential haircuts to certain counterparties.

Last but not least, we examine the CCP subsample of our database departing from the main part of the paper. It is still interesting to examine why banks clear certain repo trades through CCPs, and whether the haircuts charged by repo lenders to CCP are any different to non-CCP borrowers, since the existing understandings on CCP repo trades is limited.

[8]We also examine the structure and attributes of the repo market network and assess if the network structure has an impact on haircuts. We observe that the banks with higher centrality measures ask for lower haircuts on reverse repos and pay lower haircuts on repos. We interpret this set of findings as supportive of the adverse selection theory for funding liquidity, since the unique market position of central network players allows them to receive more trade and information flows. This set of results is not reported but available upon request.

We find that banks earn a smaller average intermediation spread (in terms of haircuts) through CCPs than through non-CCP counterparties. That is, banks' lending (reverse repo) trades have lower haircuts when transacting with CCPs, whereas their borrowing (repo) trades have higher haircuts. Furthermore, trades in which banks lend to a CCP have a higher percentage of zero haircuts. Moreover, the net position of banks with CCPs is zero, on average. Given that bank-CCP trades often involve high quality collaterals and have large notional values, this new set of findings indicates that banks' repo transactions with CCPs might be motivated by netting benefits and affected less by adverse selection.

The rest of this paper is organized as follows. In Section 2 we provide a brief description of repurchase agreements and summarize the relevant literature. Section 3 outlines the main hypotheses that we test in the data. Section 4 describes the data. Section 5 analyzes the determinants of haircuts and presents the results for the six hypotheses. Section 6 concludes.

2 Background Information on Repurchase Agreements and Related Literature

2.1 Background Information on Repurchase Agreements

A repurchase agreement is the simultaneous sale of, and forward agreement to repurchase, securities at a specific price, at a future date (Duffie, 1996). In effect, a repo is a collateralized loan where the underlying security serves the collateral role. The party that borrows cash and delivers collateral is said to be doing a repo, and the party that lends cash and receives collateral is doing a reverse repo.[9]

Repurchase agreements are broadly classified into two categories. Tri-party repo is a transaction for which post-trade services such as collateral management (e.g., selection, valuation, and verification of eligibility criteria), payments and margining are outsourced to a third-party agent which is a custodian bank.[10] A tri-party agent settles the repos on its book. Most existing repo studies are about tri-party repos. By comparison, in a

[9] The difference between the original loan value and the repayment specifies the repo rate. The haircut, or margin is determined by the difference between the loan and the collateral value. (Krishnamurthy et al., 2014). For example, if a borrower receives $98 against $100 value of collateral, the haircut is 2%. In Europe, the legal title to the collateral is transferred to the cash lender by an outright sale. In the US, this is not the case, but the repo collateral is not subject to an automatic stay and can be sold by the lender, should the borrower default (International Capital Market Association, 2019).

[10] There are two tri-party agents in the US: Bank of New York Mellon and JP Morgan. In Europe, the main tri-party agents are Clearstream, Euroclear, Bank of New York Mellon, JP Morgan, and SegaInterSettle.

bilateral repo, settlement usually occurs on a delivery versus payment basis, and the cash lender must have back-office capabilities to receive and manage the collateral (Adrian et al., 2013). Our dataset reflects this second category of repo contracts.

An interesting feature about repo/reverse repo market is that CCPs are starting to clear a growing number of repos. CCPs place themselves between the two sides of a trade, leading to a less complex network of exposures (Rehlon and Nixon, 2013). They provide benefits such as multilateral netting and facilities to manage member defaults in an orderly manner, but can also pose systemic risks to the financial system. CCPs always impose a haircut in the form of initial margin, whether in a reverse repo or repo[11]. So banks doing a reverse repo transaction with a CCP will need to give a haircut, which amounts to a negative value for the haircut. Our dataset covers CCP trades with the reporting banks and hence offers an opportunity for us to examine characteristics and assess the benefits of these trades.

2.2 Related Literature

The financial crisis rekindled interest in the theoretical and empirical study of the short-term funding market. The theoretical work on collateralized borrowing can be categorized into two streams. One is based on the difference of opinion approach in a general equilibrium setting such as in Geanakoplos (1997; 2002; 2003); Fostel and Geanakoplos (2012); and Simsek (2013). The other is based on contractual and/or information frictions such as in Dang et al. (2013); Dang et al. (2011); Ozdenoren et al. (2018) and Gottardi et al. (2019). We discuss the theoretical literature in detail when forming testable hypotheses in the next section of the paper.

There is also a body of literature that models crisis and runs in the repo market. One approach is based on the classical setting of Diamond and Dybvig (1983) extended to the repo setup as in Martin et al. (2014). In this framework, the liquidity needs of the lender, the capital position of the borrower, and the market microstructure of the repo market play important roles in determining the magnitude of the run. Acharya et al. (2011) model freezes in the market for short-term financing in form of sudden collapse in debt capacity of collateral in an information-theoretic framework. Gorton and Ordonez (2014) focus on the information in-sensitivity of debt contract and how a sudden switch of information

[11] Although if the collateral is a portfolio of assets, the haircut may be imposed on a subset of them to meet the initial margin requirement. Counterparties to CCP also need to meet variation margin requirements. Since CCPs are purely intermediaries, these variation margins are pass through between lenders and borrowers.

environment might trigger a deep discount and collateral crisis. Ozdenoren et al. (2018) emphasize the inter-temporal feedback of (expected) future asset price and the decisions of today's borrowers and lenders. In that setting, dynamic mis-coordination might lead to a run in the repo market.

The empirical studies of repurchase agreements are mostly focused on the US repo market. Several papers study developments in this market during the financial crisis. Broadly speaking, two distinct phenomena can be identified in the US bilateral and tri-party repo markets. In the bilateral market, as argued by Gorton and Metrick (2012), a run occurred during the 2008-2009 financial crisis in the form of rapid increases in haircut levels. This is further supported by multiple hedge funds failing due to margin calls (Adrian et al., 2013). Adrian and Shin (2010) empirically show that repo transactions have contributed the most to the procyclical adjustments of the leverage of banks. From this perspective, the rapid increase of haircuts in bilateral repos during the crisis can also be viewed as (forced) deleveraging of broker-dealers (Adrian et al., 2013).

In contrast, in the tri-party market haircuts moved very little during the 2008-2009 financial crisis and the amount of funding remained fairly stable but, instead, lenders refused to extend financing altogether to the most troubled institutions—namely, Bear Stearns and Lehman Brothers (Copeland et al., 2010). Krishnamurthy et al. (2014) argue that there was a run in the tri-party market but only for non-agency MBS/ABS, which constituted a relatively small and insignificant part of the short-term debt market. In the tri-party market, tension seemed to affect specific institutions rather than the broad collateral classes, except maybe for the private-label securitized assets (Adrian et al., 2013). Martin et al. (2014) relate the differences between the behavior of these two markets with respect to their microstructure: In the tri-party market, haircuts are fixed in custodial agreements that are revised infrequently, but this is not the case in the bilateral market.

There is a limited number of empirical studies on bilateral repos. Most US studies on repos are on tri-party contracts starting with Copeland et al. (2014); Krishnamurthy et al. (2014) and Hu et al. (2021). They generally find that the market is quite segmented and market power, collateral concentration and fund families might play important roles. To our knowledge, empirical studies on bilateral repos are rare due to lack of data availability. Therefore, the work by Gorton and Metrick (2012) using a proprietary database is important for the understanding of repo transaction where various types of collaterals are present. The dataset in Gorton and Metrick (2012) contains credit spreads on various products and repos between high-quality dealer banks. However, the dataset has limited deal level information. To control for counterparty risk, they use a market-wide pricing variable (the LIBOR-OIS spread), due to the lack of individual counterparty data. Auh and Landoni (2022) use bilateral repos data from the portfolio of multiple hedge funds under the same management. The authors find that lower-quality loans (backed by lower-rated collateral) have longer maturity, higher margins and spreads. However, since the dataset has only one borrower (the family of funds), it does notallow to analyse the role of counterparty borrower risk. Finally, Baklanova et al. (2019) use three snap shots of data from nine BHC-affiliated securities dealers to study the use of collateral in bilateral repurchase and securities lending agreements. Their database is extensive, covering 51-53% of US bilateral Repo market for these three time snapshots. However, the data contains only counterparty types but not other individual characteristics. The authors find a mixed result regarding the relationship between haircuts and potential price swings of the collaterals: the expected negative relationship is only found for transactions with positive haircuts. These inconclusive results on haircut drivers are in contrast with those in our paper.

Our dataset instead covers about 24% of the total repo activity in the UK market during the sample – a market estimated by the SFTR to be about twice the size of the the US one – and offers an extremely rich set of contracts characteristics, underlying assets, and counterparty information. The richness of the dataset, hence, allows us to shed light on the key drivers of haircuts in bilateral repos by formally testing theoretical predictions.

The repo studies in the European area are mostly conducted on general collateral repos or through CCPs where regulations play a very important role (Mancini et al. (2016), Boissel et al. (2017), Corradin and Maddaloni (2020)). Other recent studies focused on safe assets and collateral use (Aggarwal et al. (2021) and Jank et al. (2021)). Compared to these studies, our repo haircut dataset is unique in that it covers a significant part of a bilateral repo market. In addition, our data set has a rich cross-sectional variation in the riskiness of the underlying collateral and in counterparty characteristics, which allows us to tease out the factors driving repo haircuts.

3 Testable Hypotheses on Haircuts

We start with a stylized model to develop the testable hypotheses on haircut of repo loans. Suppose we are in an economy with two dates, date 0 and date 1. All agents are risk neutral. There are agents who need funds for starting productive projects with a deterministic gross return $z > 1$. There is also a representative lender with deep pockets. To overcome the limited commitment problem, the borrowers need to use the collateral asset to back the borrowing, that is, they use a form of repo loan.

We assume that the collateral asset yields a random payoff $\tilde{\delta}$ at the end of the period.[12] The asset can be of high or low quality. The probability of low type is λ. Quality is i.i.d and privately known to the borrower. For expositional clarity, we derive the comparative statics using a two-point distribution. Specifically, the high (low) quality asset pays one unit of payoff with probability π_H (π_L) and pays $e \in (0, 1)$ otherwise where $0 \leq \pi_L < \pi_H \leq 1$. We assume that, when the ownership of the collateral asset is transferred, a fraction $\gamma \in (01, 1)$ of the asset value is destroyed (e.g., due to illiquidity, transaction cost or lost of convenience yield). To raise funds, borrowers can issue a security that promise to pay y backed by the collateral payoff. The debt contract takes a simple form. It pays $y = \min\{d, (1-\gamma)\tilde{\delta}\}$. That is, in the case of default, the lender can only obtain a $1-\gamma$ fraction of the collateral value.

Next, we discuss the market microstructure. We assume that the lending market is competitive. The representative (risk neutral) lender, hence, earns zero profit. The cost of lending for the representative lender is normalized to 1. There are gains from trade since $z > 1$. We also assume that the gains from trade parameter is small enough, that is, $z < 1/(1-\lambda)$ so that it will not make the impact of the information friction irrelevant in this model. Furthermore, the collateral price ϕ is set as $\phi = \mathbb{E}\{\tilde{\delta}\}$ due to the risk neutral assumption. The loan amount offered by the lender is denoted by q. The haircut is, hence, defined as $h = 1 - q/\phi$.

This is a model of lemons since the borrowers with the low quality collateral always issue asset-backed securities to raise fund in order to access z returns. The borrowers with the high quality collaterals, however, might not participate since their asset-backed security would be pooled with the low quality borrowers and priced at a lower value. Hence, the participation constraint is

$$z\mathbb{E}\{y\} = z\left(\lambda\mathbb{E}_L\{y\} + (1-\lambda)\mathbb{E}_H\{y\}\right) \geq= \mathbb{E}_H\{y\} \tag{1}$$

where the left side is the payoff from issuing an security priced at the pooling price and investing in z return project, and the right side is the payoff from holding on collateral.

Next, we define the information sensitivity ratio of a security issued by the borrowers in this economy, denoted by $\zeta(y) \equiv \mathbb{E}_L\{y\}/\mathbb{E}_H\{y\}$. The smaller is $\zeta(y)$, the more there is a difference in payoffs of high and low collaterals, and the more information sensitive is the security's payoff, which in turn leads to more adverse selection. When condition

[12] We denote random variable with $\tilde{}$.

(1) holds with equality, we obtain a threshold $\bar{\zeta}$ which is the lowest possible information sensitivity ratio of a security that the borrowers with high quality collaterals are willing to issue knowing that they will be pooled with the borrowers with low quality collaterals.

$$\zeta(y) \equiv \frac{\mathbb{E}_L\{y\}}{\mathbb{E}_H\{y\}} \geq 1 - \frac{z-1}{z\lambda} \equiv \bar{\zeta} \tag{2}$$

where $\bar{\zeta}$ measures the adverse selection level of the lemon market. It is decreasing in the productivity parameter z and increasing in the probability of low type, λ.

The information sensitivity ratio of the repo debt is

$$\zeta\{d, \tilde{\delta}\} = \frac{\mathbb{E}_L \min\{d, (1-\gamma)\tilde{\delta}\}}{\mathbb{E}_H \min\{d, (1-\gamma)\tilde{\delta}\}}. \tag{3}$$

We assume that parameters π_L π_H, e are such $\zeta\{1, \tilde{\delta}\} < \bar{\zeta}$ so the information friction is severe enough for the haircut problem to be non-trivial.

We are now ready to characterize the face value of the loan. We first obtain the pricing of the loan contract q which satisfies the following zero profit condition:

$$\begin{aligned} q &= \mathbb{E}\{\min\{d, (1-\gamma)\tilde{\delta}\}\} \\ &= \mathbb{E}\{\tilde{\delta}\} - [\lambda\pi_L + (1-\lambda)\pi_H](1-d) - \gamma e\left[(1-\pi_L)\lambda + (1-\pi_H)(1-\lambda)\right] \end{aligned} \tag{4}$$

The indifference condition for the high type borrowers to participate in this market for lemons is

$$\zeta\{d, \tilde{\delta}\} = \bar{\zeta}. \tag{5}$$

We assume that lenders want to maximize the lending by setting the face value high enough to meet this indifference condition. Hence, the face value of the debt, d, can be obtained by solving equation (5), which is

$$d = (1-\gamma)e\left(1 + \frac{1-\bar{\zeta}}{\bar{\zeta}\pi_H - \pi_L}\right). \tag{6}$$

Combining equations (4) and (6), we obtain the haircut for repo loans,

$$\begin{aligned} h &= \frac{1}{\phi}\left[1 - (1-\gamma)e\left(1 + \frac{1-\bar{\zeta}}{\bar{\zeta}\pi_H - \pi_L}\right)\right][\lambda\pi_L + (1-\lambda)\pi_H] \\ &\quad + \frac{\gamma}{\phi}e\left[(1-\pi_L)\lambda + (1-\pi_H)(1-\lambda)\right] \end{aligned} \tag{7}$$

where $\phi = \mathbb{E}\{\tilde{\delta}\}$. Equation (7) shows that the repo loan haircut depends on the distribution parameter $\pi_H - \pi_L$, illiquidity γ, and adverse selection parameter $\bar{\zeta}$. We categorize these parameters into two types. One type is related to the risk of asset payoff such as $(\pi_H - \pi_L)$ and illiquidity (γ). The other type is related to adverse selection. The following results follow directly from (7).

PROPOSITION 1: Haircuts are larger for risky assets and illiquid assets.

Equation (7) also shows that higher the adverse selection parameter $\bar{\zeta}$, larger the haircut, which leads to the following result.

PROPOSITION 2: Haircuts are increasing in the degree of adverse selection.

Additionally, we find the participation constraint is relaxed when the borrowing is backed by a portfolio of one unit of risky collateral and one unit of the safe asset that pays 1 unit regardless of states since

$$\zeta^{safe}(d, \tilde{\delta}) = \frac{1 + \mathbb{E}_L \min\{d, (1-\gamma)\tilde{\delta}\}}{1 + \mathbb{E}_H \min\{d, (1-\gamma)\tilde{\delta}\}} > \frac{\mathbb{E}_L \min\{d, (1-\gamma)\tilde{\delta}\}}{\mathbb{E}_H \min\{d, (1-\gamma)\tilde{\delta}\}}. \tag{8}$$

Intuitively, the portfolio that combines safe with risky collaterals is less information sensitive. Therefore, the adverse selection is lower and the haircut on this portfolio is smaller.

PROPOSITION 3: Haircuts are lower when safe assets are included in the portfolio of collateral assets.

Based on this model, we develop the following testable hypotheses based on asset risk characteristics. Our first testable hypothesis follows directly from Proposition 1.

Hypothesis 1 (collateral quality): The repo haircut is larger when the collateral is of lower quality and/or illiquid.

Since asset quality is closely related to default probability, we measure collateral quality using VaR, maturity, rating, and asset types. Transaction maturity should also matter since as the duration of the repo contract increases, the potential loss from worsening collateral quality becomes greater.

However, asset quality variables are not the only determinants of haircut if there are information frictions between the borrowers and the lenders as shown in Proposition 2 in the above model. Hence the counterparty types also matter. The information friction is larger when borrowers are from a different line of business from lenders. This leads to our second hypothesis.

Hypothesis 2 (counterparty types): The repo haircut is larger when the counterparties in the contract are from different lines of business and hence have different opinions about the collateral value.[13]

Another proxy of information friction is the credit quality of the counterparty matters rather than the difference in types. This leads to our third testable hypothesis.

Hypothesis 3 (counterparty quality): The repo haircut is larger when the default probability (credit quality) of borrower is higher (lower).

In fact, the existence of bilateral relationship between borrower and lender lowers the information friction and is also important in the determination of haircuts. This leads to our fifth testable hypothesis.

Hypothesis 4 (bilateral relationship): Haircuts are lower for bilateral parties with stable banking relationships.

Similar to Proposition 3, Ozdenoren et al. (2018) also show that there are ways to mitigate adverse selection. For example, a portfolio of collateral assets will have a larger borrowing capacity if it includes some safe asset.This leads to our last testable hypothesis.

Hypothesis 5 (portfolio repos): Risky assets in a portfolio repo with safe assets have lower haircuts than purely risky asset repos.

The last hypothesis draws on the literature that models coordinations and runs in the repo market. Gorton and Ordonez (2014) find that endogenous information acquisition can cause a sudden increase in haircuts and a collateral crisis. Hence, lenders' characteristics might matter. Similarly, in a dynamic sequential trade model, Dang et al. (2011) find that the haircut size is increasing in the liquidity needs of the lender, and in the default probability of the lender in a subsequent repo transaction. In a series of dynamic Diamond and Dybvig (1983) models with an asset collateral market, Martin et al. (2014) find that collateral and liquidity constraints matter, and hence the liquidity of lenders affects haircuts. This leads to the final testable hypothesis.

[13] The source of information friction could also be based on difference opinion as shown in Geanakoplos (2003) and Simsek (2013).

Hypothesis 6 (lender's quality and liquidity): The repo haircut is larger when the default probability and/or liquidity need of the lender is higher.

4 Overview of the Data

The transaction-level dataset is a snapshot of the repo books of six banks that are major players in the UK repo market. The total size of their repo books—the sum of repos and reverse repos—is around £511 billion (including CCP transactions) as at the end of 2012.[14] According to Financial Stability Board (2013), the UK-resident deposit-taking banks hold around £2.1 trillion in gross repo activity on their balance sheets, hence our dataset accounts for around 24% of the total repo activity in this market. The majority of this activity is with non-UK resident banks, including the activity between UK and foreign branches of the same consolidated group, and is highly concentrated (Financial Stability Board, 2013).

Each of the six banks reports its outstanding repo transactions as at the end of 2012, including the gross notional, maturity, currency, counterparty, haircuts and collateral information. We supplement this dataset with additional data on securities, counterparties, and the reporting banks from Datastream and Bloomberg. In what follows, we report information and results for reverse repos (REVR) and repos (REPO) separately. This classification is from the point of view of the reporting banks. Hence, *in a reverse repo the reporting bank is lending* to a counterparty, and *in a repo the reporting bank is borrowing* money from a counterparty.

4.1 General Sample

Table 1 presents an overview of our dataset in terms of key repo and reverse repo contract characteristics. It shows the breakdown of the data along four categories: maturity, currency, counterparty type, and collateral type (Panels A, B, C, and D, respectively). Since repo indicates bank borrowing, we denote the repo values with negative numbers.

By comparing the values of reverse repos and repos, we find that the reporting banks are net borrowers in the repo market (see the row labeled "Total" in Table 1). Panel A of the table shows that most of the borrowing and lending transactions for these reporting banks have maturities less than three months. While borrowing exceeds lending for overnight

[14]The actual reporting periods differ slightly across the banks, but all are toward the end of 2012.

contracts, lending is larger for transactions with maturities of less than three months. This observation suggests that the reporting banks conduct maturity transformation, to some extent. However, for maturities longer than one year they are still net borrowers. Panel B of the table shows that the reporting banks borrow and lend the most in GBP and EUR followed by USD. In net terms, they borrow in GBP and lend in other currencies.

Panel C of Table 1 shows that the reporting banks, in aggregate, borrow more via CCPs and from counterparties such as other banks, central banks and governments, broker-dealers and hedge funds. The reporting banks lend more via CCPs and to counterparties such as other banks, hedge funds, broker dealers, and other asset managers. This is in line with our general understanding of the money flow pattern in the wholesale funding market where banks and CCPs intermediate repo trades.[15] Finally, Panel D of Table 1 shows the breakdown based on collateral types. It shows that when the six banks borrow, only a small percent of their repo collateral is US government bonds. It also appears that the reporting banks intermediate in (and borrow against) relatively worse collaterals such as securitization products and corporate debt. UK government bonds are the most common collateral used both in repo and in reverse repo contracts followed by other high quality sovereigns such as German government bonds.

Inspecting the maturity-currency relationship in Figure 1, we see that the majority of contracts (frequency, not notional values) are in EUR and USD followed by GBP and JPY. Most of the contracts have maturity less than 3 months across all currency groups and only a very small fraction of the contracts have maturity more than half a year within each currency category. GBP has a relatively higher fraction of reverse repo contracts within 3 to 6 months, compared to other currencies. Repo (reverse repo) transactions in JPY and other currencies happen almost exclusively with maturity up to 1 (3) month(s).

In Table 2, we examine the breakdown of contract characteristics for the CCP subsample. There are six CCPs in our sample. Compared with the full sample, the CCP subset is less heterogenous in terms of maturity, currency denomination and types of collaterals. CCP trades are mostly short-term with 1 day to three-month maturity and without any maturities above five years. GBP-denominated transactions are above 82% for repo and above 55% for reverse repo CCP trades. UK government bonds are featured as collaterals in 86.7% of the repo and 59% of the reverse repo CCP trades.

Finally, to contrast the effect of the collateral quality, we provide summary statistics for

[15]The first row in Panel C describes the values when counterparty is a reporting bank. The reporting banks report on a UK-consolidated basis, but counterparties are reported on a global basis. Therefore, there may be discrepancies between the reverse repos and repos with the reporting banks.

two extreme subsamples: 'clearly cash' and 'clearly credit' instruments – without the subsample of medium-quality instruments. This exercise also serves to compare with studies using the US tri-party repo data where collaterals are high-quality US treasuries. We refer to government bonds from the UK, the US, Germany, France, Japan, France, Belgium, the Netherlands or Austria as cash instruments since their ratings were above AA during the sample period. We follow the convention of the academic literature in defining corporate bonds and securitized products as credit instruments. The breakdown of these two types of contracts across maturity, currency, and counterparty types is shown in Table 3. It is important to note that Table 3 does not include the medium-quality instruments.

There are several notable differences between 'clearly cash' and 'clearly credit' repos. First, 'clearly credit' contracts are mostly overnight in reverse repo, and longer-term (1-5 years) in repo. This fact shows that when banks lend against riskier collateral (reverse repo), they do so only for very short maturities (overnight), whereas when they borrow against this risky collateral, they are able to do so for much longer contract maturities. In contrast, 'clearly cash' collaterals are used both for repos and reverse repos with maturity up to 1 year and the distribution across maturities is fairly similar. Second,'clearly credit' collaterals have a larger share of USD and EUR-denominated trades, while 'clearly cash' collaterals are in GBP mostly. The share of hedge funds as counterparty for 'clearly credit' collaterals is larger when the reporting banks are lending compared to when they are borrowing. The larger share of hedge fund borrowers in 'clearly credit' repos might explain the short overnight maturities of these contracts given the higher riskiness of hedge funds. In contrast to 'clearly credit' repos, 'clearly cash' repos have the majority of deals (both repo and reverse repo) with CCPs.

Comparing the total of 'clearly cash' repo and reverse repo in Table 3 (£305.5 billion) to the total in Table 1 (£511.2 billion) shows that a significant portion of the repo market – about 40% – is backed by non-cash-like collaterals. This is a phenomenon that is unique to the European market and is a significant departure from the patterns observed in the US repo market. Among the 40%, about 7% is backed by 'clearly credit' collateral, which can be considered low quality relative to cash collateral. The discrepancy between our sample and the general US market stems from the fact that risky sovereign bonds such as those issued by GIIPS (Greece, Italy, Ireland, Portugal, and Spain) and developing countries are accepted as collaterals by central banks in the European markets, but not in the US market. Since the repo literature is dominated by studies that use US data, we preserve the conventional cash-credit dichotomy for the subsequent haircut analysis in the paper (omitting the medium-quality collaterals). This set of analysis is in addition to the main analysis using the whole sample, serving to pinpoint whether the results observed in the whole sample are mainly driven by the cash sample and/or the credit sample.

We also analyse to what extent collateral is reused in our dataset by computing what percentage of the collateral received by banks in reverse repos is then reused to borrow as part of repo transactions. In particular, we report in Table 4 the average rehypothecation rates by maturity and type of transaction. The overall pattern of rehypothecation across maturities is similar to recent findings for the US, as in Figure 4 of Infante et al. (2020). Table 4 shows that rehypothecation is more common for cash compared to credit collaterals, particularly at longer maturities. Credit collaterals with maturity of 10 years or longer are rehypothecated at much lower frequency (8.3%–16.6%) than cash collaterals (24.9%–56.3%).

Since we explore the heterogeneity of non-CCPs deals in a large part of our regression analysis, Table 5 presents summary statistics on haircuts for the non-CCP subsample along four categories: maturity, currency, counterparty type, and collateral type (Panels A, B, C, and D, respectively). This sample is also smaller than that in Table 1 due to missing haircut information for some observations. The average haircuts for each category in Table 5 are weighted by the gross notional of transactions.

Panel A of Table 5 shows that, except for long maturities, the reporting banks are able to borrow at slightly lower haircuts than they lend. This observation means that they can use the collateral received in a reverse repo to obtain cheaper funding. A similar pattern exists for different currencies as shown in Panel B.

Panel C makes it clear that the above-mentioned haircut advantage for reporting banks arises from trades with hedge funds, other asset managers and, to a lesser extent, with other banks and broker-dealers. In the transactions with these counterparties, the banks can receive funding at significantly lower margins. The intermediation spread can be as high as 1.3% for hedge funds and as low as 30 bps for broker dealers. This advantage disappears when our banks trade with central banks and government agencies, insurance companies and pension funds, and other reporting banks.

Finally, Panel D in Table 5 shows the breakdown based on collateral types. It displays how margins depend on the quality of collateral. For example, both repos and reverse repos for German government bonds have a low average haircut, while haircuts for corporate debt and securitization are higher. The numbers also show that the six reporting banks are able to borrow at a lower haircut compared to the one they charge for the same type of collateral. This is true for all collateral types, except securitized debt. Note that the UK government collateral commands a relatively high haircut, but this is largely due to the longer maturity of the collateralized assets.

4.2 Zero-haircut subsample

There are a lot of zero haircut observations in the data as illustrated by the histogram of haircuts in Figure 2: over 35% of the whole sample. Some of these zero haircuts are due to the way haircuts are reported in CCP trades as explained in the next Section, but even excluding CCP trades, zero-haircut trades are still quite common.[16] This finding is not surprising and has been confirmed by other data collections undertaken at the global level. A summary of the zero-haircut trades among the non-CCP sample is presented in the last two columns of Table 5. The table shows that the vast majority of contracts are with other banks and are denominated in EUR. In terms of notional values, most repo contracts are overnight, whereas reverse repos have maturities below 3 months. As for number of contracts, most of the zero-haircut contracts are overnight (84% of all repo contracts, 72% of all reverse repos), as shown in Figure 3.

The network graphs in Figure 4 illustrate the topology of the zero-haircut trades. The size of each node reflects the number of counterparties with which a reporting bank has at least one zero-haircut deal. Edge widths show the total number of zero-haircut trades between two given nodes. The figures show that the zero haircut observations from the repo and the reverse repo samples are dominated by one or two banks. In the repo market, one of the banks (bank A in Figure 4) receives majority of the zero-haircut trades. This borrower has 89 zero-haircut lending counterparties but one particular counterparty accounts for 24% of these trades – C697 in Figure 4. In the reverse repo market, another bank (bank B in Figure 4) is involved in the majority of all the zero-haircut trades. The top 10 counterparties account for 68% of all zero-haircut repo trades and 71% of all zero-haircut reverse repo trades, which shows that a small number of counterparties contribute to the majority of zero-haircut observations. These facts suggest (and the fixed effect analysis in Section 5.2 confirm) that there are important borrower-lender relationships among the determinants of the zero-haircut trades, supporting our fourth testable hypothesis highlighted above. We investigate the role of bilateral relations further in later sections.

[16] We find that zero haircut trades are about 36% of the CCP sample and 30% of the non-CCP sample.

5 The Drivers of Haircuts

5.1 Empirical approach

For the most part of the regression analysis, we focus on the sample excluding the trades with CCPs. In practice, CCPs often calculate haircuts (or initial margin requirements) on a portfolio basis. That is, the over-collateralization of repo positions is calculated at the portfolio or netting set level, without applying haircuts on individual transactions. In our dataset, firms still report a transaction-level haircut, but this is often zero given that the 'true' haircut is applied at the portfolio level. In such cases, it is not meaningful to look at haircuts on individual transactions that are centrally cleared. Therefore, we focus on the sample that excludes CCP transactions to conduct the main analysis. Nevertheless, we also study the possible reasons for choosing CCP to conduct trades in section 5.4.

In Table A.1 of the Appendix, we describe all the explanatory variables used in the regressions. We have dummy variables for currencies, collateral types, counterparty types, bank-counterparty pairs and a dummy for collateral bundled in a portfolio with a very safe asset (rated AAA). Other than dummy variables, we use trade-specific variables, collateral-specific and counterparty-specific characteristics. We also have two measures for counterparty and collateral concentration. Counterparty concentration measures the share of transactions with a specific counterparty in total, evaluated using the notional amount of transactions. It represents how systemically important that counterparty is to the bank. Similarly, collateral concentration is measured by the share of transactions against a specific collateral in total, evaluated using the notional amount of transactions. We also include an interaction between counterparty and collateral rating to check for substitution effects between the two types of ratings.

To confirm that the multitude of zero haircuts does not distort our results, in addition to the ordinary least square regressions, we also report Tobit estimation with truncation at zero (in the Appendix, Table A.2). We split the data and consider separately repo and reverse repo transactions since they are different samples: one has reporting banks as borrowers and the other has the reporting banks as lenders. Moreover, we observe heterogeneity in the counterparties in the two types of transactions which allows us to conduct a more detailed analysis of haircut determinants.

Table 6 reports summary statistics for haircuts and non-dummy explanatory variables for the sample used in the baseline regressions. Except collateral and counterparty ratings which are categorical, other variables in this table are continuous. The summary statistics are represented separately for reverse repos and repos in Panels A and B, respectively, given that haircut practices can potentially differ significantly between the two instruments. Variables are winsorized at the 0.5% level.

Even though haircuts can have a value as high as 46%, the weighted average of haircuts is about 6% for reverse repos and about 2% for repos. The weighted average of maturity for the transactions is about 22-29 days. Average collateral maturity used is between 7.5 and 12 years. Collateral and counterparty ratings are modified into numeric scale from 1 to 20, with 20 being the highest rating. The average collateral quality in this scale is about 14, while the average counterparty rating is between 14 and 15 (which corresponds to between A- and A).

The summary statistics for counterparty return on assets (RoA), leverage, CDS spread, and cash ratio are also presented in Table 6, and the respective definitions are in Table A.1. We include RoA to see how profitability of the counterparty can affect haircuts. Cash ratio is intended to proxy for liquidity needs. Overall, the summary statistics for reverse repos and repos are not significantly different.

We also present the same statistics for the 'clearly cash' and 'the clearly credit' subsamples in Table 7. One notable difference between the two subsamples is, understandably, the collateral rating: the average rating for the cash sample is close to 20 (which is the highest possible credit rating AAA), whereas for the 'clearly credit sample it is around 13 (BBB+). Counterparties have higher leverage but lower rating in the 'clearly cash' subsample compared to the 'clearly credit' subsample, on average.

Table 8 reports the baseline estimation results for the whole sample using the OLS specification. We conduct the analysis separately for reverse repo and repo contracts because for the same bilateral pair, the bargaining power often lies with one party regardless of whether this party is borrowing or lending. Therefore, haircuts would be different when the party with the larger bargaining power is borrowing (repo) compared to when it is lending (reverse repo), indicating that the counterparty fixed effect estimation should be different for the reverse repo and repo contracts. We also report the subsample analysis for cash and credit deals in Tables 9 (reverse repo) and 10 (repo), to isolate the information effect of the collateral on the haircut determination.

In these three tables, the dependent variable is haircut. The explanatory variables are classified into five categories: deal characteristics, collateral characteristics, counterparty types, counterparty characteristics, and miscellaneous variables. These categories are shown in the first column. Columns labeled with numbers display regression coefficients for different sets of explanatory variables. All continuous explanatory variables are standardized in order to simplify the comparison of coefficients for different variables. Standard errors, which are not reported for simplicity, are clustered at the counterparty level.[17] All regressions include bank fixed effects (FEs), relationship fixed effects and currency fixed effects. A relationship FE is a dummy taking the value of 1 if the given dealer-counterparty pair has more than 10 trades in the regression sample.[18] The main regression for Table 8 is:

$$Haircut_j = \beta \times determinants_j + BankFE + RelationshipFE + CurrencyFE + \epsilon_j, \quad (9)$$

where β is vector of estimates on the haircut determinants.

In columns (1)-(5) of Table 8 we report the results for reverse repo transactions. In these transactions, the reporting bank lends cash and receives collateral, whereas the counterparty borrows money and delivers collateral to the bank. Hence, counterparty characteristics correspond to borrower characteristics. In columns (6)-(10), we present analogous results for repos. In these transactions, the reporting bank borrows cash and delivers collateral, whereas the counterparty lends money and receives collateral. Hence, counterparty characteristics correspond to lender characteristics in these transactions. In both cases, we first report the result with the smallest set of explanatory variables (deal characteristics), then we include collateral variables, counterparty types and characteristics variables, and finally a set of miscellaneous variables.[19]

In Tables 9 (reverse repo) and 10 (repo), we present results for the two subsamples: 'clearly cash' and 'clearly credit' deals. The regressions therein are of the form

$$\begin{aligned} Haircut_j =& \beta \times determinants_j \times D_{j,credit} + \gamma \times determinants_j + \\ & BankFE + RelationshipFE + CurrencyFE + \epsilon_j, \end{aligned} \quad (10)$$

where the γ coefficients measure the base effect (corresponding to clearly cash), shown in columns (1)–(5), and the β coefficients capture the marginal effect, i.e. the relative effect on 'clearly credit' compared to 'clearly cash', shown in columns (6)–(10). Note that this analysis serves to establish a benchmark result for 'clearly cash' collaterals, and

[17]We have explored using two way clustering at the bank and counterparty levels, yielding similar results. However, given that we have only six banks in our sample, we have too few clusters at the bank level. Hence, we report standard errors using single clustering in all our tables.

[18]The results with larger cutoff are similar.

[19]In Table A.3 in the Appendix, we also run a robustness test for the main regression specification including month fixed effects, which shows that the main results are unchanged.

investigate the additional effect of 'clearly credit' collaterals.

In all tables, reverse repo regressions have a better fit (measured by R^2) than repo regressions. Importantly, the marginal R^2 pertaining to the various groups of explanatory variables is lower for repo than for reverse repos. For example, in Table 8, adding all our regressors in the repo case gives an $R^2 = 0.532$ (column 10) compared to having only the two contract-specific variables (column 6) with $R^2 = 0.511$. For reverse repos, adding all the regressors increases the R^2 from 0.539 to 0.669. Overall, this shows that our empirical model is better at explaining reverse repos than repos. This observation is also corroborated by the fewer significant coefficients in the case of repos compared to reverse repos.

The above observation can be partially explained by the nature of our sample. The reverse repo sample consists of the lending transactions by the six major banks to a variety of counterparties who use various types of collaterals. Hence, there is more heterogeneity in both collateral and counterparty characteristics for the regression analysis, which could explain the better fit. In contrast, the repo sample contains borrowing transactions by the same six major banks who use a relatively narrower list of collaterals and borrow from a relatively smaller set of counterparties (since typically only cash-rich counterparties lend to the banks). These unique features of our sample could help explain the difference in regression fit across the repo and reverse repo subsamples. Next, we elaborate on the main results presented in Tables 8–10 in light of the six hypotheses formulated in Section 3.

5.2 Tests of hypotheses

Test 1 (collateral quality): The haircut is larger when the collateral is of lower quality and/or illiquid.

As aforementioned, collateral quality can be measured using VaR, maturity, rating, and/or asset types. Transaction maturity is also a proxy because the longer the maturity, the riskier the underlying collateral becomes. Another measure of collateral riskiness is its concentration: when the concentration ratio increases, the collateral portfolio pool becomes riskier. To test hypothesis 1, we include VaR of each asset, collateral rating, maturity, transaction maturity, collateral concentration, and notional value in all baseline regressions. We compute VaR using two approaches. First, the measure is obtained using the historic approach, i.e. using the quintiles of the historical return distribution. We calculate simple returns and take the 5-days, 5% VaR as our main measure.[20] Second, we also compute VaR using the parametric approach (i.e., using the deciles of the normal distribution). The results are largely similar to the results obtained using the historic approach. In the main text, we provide the results obtained with the historic VaR.

Table 8 shows that the longer the contract maturity, the larger the haircut, and this relationship is statistically significant across most specifications. The estimate of 0.054 in column (5) of Table 8 shows that one standard deviation increase in maturity of reverse repo contracts (2 months) raises haircuts by 5.4%. Similarly, the coefficient of 0.035 in column (10) shows that one standard deviation increase in maturity of repo contracts (4 months) raises haircuts by 3.5%.

Among the collateral qualities, the results in Table 8 show that VaR has the most consistent, statistically significant impact on haircuts – both in reverse repo and repo markets. One standard deviation increase in the 5-day, 5% VaR is correlated with 100 bps rise in the repo haircut and with a 60 bps rise in the reverse repo haircut. The effect is robust to adding different controls – the estimates in columns 1-10 barely change. When inspecting the impact of VaR in the cash and credit subsamples, we find that this effect is robust for reverse repo cash transactions but the marginal effect for credit collaterals is not significant (see Table 9). This reinforces the conjecture that, given its short horizon, VaR captures mostly liquidity rather than credit quality.[21] VaR is insignificant for repos both in the cash and credit subsamples (see Table 10).

We find that collateral rating has a statistically significant impact on reverse repo haircuts. One unit increase in collateral rating lowers the haircut by about 1.2% for reverse repos (Column (5) in Table 8). That is, the reporting banks rely on collateral rating to assess the haircut when lending. However, the statistical significance of this result disappears for the repo sample. The latter fact indicates that when reporting banks borrow, their counterparties rely less on collateral rating (a credit risk indicator) but more on VaR (a liquidity indicator) to set the haircut.

For the whole sample, higher collateral concentration – another measure for the riskiness of the collateral portfolio – increases the haircut, both for reverse repo and repo transactions (columns (5) and (10) in Table 8). Therefore, our reporting banks are charged (charge) significantly higher haircut when borrowing (lending) relatively large sums against the same collateral. The results are more subtle for the cash and credit subsamples. Collateral concentration matters more when our reporting banks are lending against cash

[20]Using 1% or 10 days produces similar results.

[21]VaR is a measure of market liquidity risk in standard risk management textbooks.

collaterals (column (5) in Table 9), or when the reporting banks are borrowing against credit collaterals (column (10) in Table 10). This finding might reflect the fact that our reporting banks are already in possession of large amounts of cash collaterals due to their large size, and the appetite for risky credit collaterals of their (on average smaller) counterparties is relatively limited.

In general, there is strong evidence that collateral quality and liquidity variables are important determinants of repo haircuts.

Test 2 (counterparty types): The haircut is larger when the counterparties in the contract are from different lines of business and hence have different opinions about the collateral value.

Table 8 shows that the reporting banks charge higher haircuts when lending to hedge funds and are charged higher haircuts when borrowing from central banks. However, there is more complexity to this finding. In Table 9 we further examine this effect in the cash and credit subsamples. We find that hedge funds are charged much higher haircuts when using credit instruments as collaterals: the haircut increases by staggering 28% when banks lend to hedge funds in a credit repo. This finding is consistent with the idea that belief disagreement is more pronounced for credit repos. Somewhat surprisingly, banks charge lower haircuts when hedge funds use cash instruments. The latter observation might be related to the fact that the type of hedge funds that borrow using cash collateral is different from the one using credit collateral (Kruttli et al. (2021)). We also observe similar cash-credit sample findings for insurance companies and pension funds, although the aggregate impact on the haircuts paid overall (shown in Table 8) is not statistically significant.

Since there is more disagreement about the value of credit collaterals relative to cash collaterals, these observations support the view that when the two parties in a repo contract disagree on the collateral value, charging a higher haircut is a tool to mitigate the disagreement. We do not find that banks charge significant haircuts when lending to broker dealers, other banks, or asset managers. This pattern might reflect the fact that there is lower information friction, and hence less adverse selection, between counterparties of similar types. This evidence is consistent with both the difference of opinion (see, e.g., Geanakoplos (1997)) and the adverse selection (see, e.g., Ozdenoren et al. (2018)) paradigms.

However, although our reporting banks are charged higher haircut when borrowing from several types of counterparties in our sample, only haircuts from central banks are significantly larger from a statistical standpoint – about 4.9% higher (column (10) in Table

8). This effect is present only if banks use cash collateral. Overall, the lack of significant counterparty type fixed effects in the repo sample (except the central banks one) may reflect the fact that there is little disagreement about the value of collaterals used by the reporting banks (since collaterals are mostly of the "cash" type – see Table 3), and higher costs in accessing central bank liquidity.

Test 3 (counterparty quality): The haircut is larger when the default probability (credit quality) of the borrower is higher (lower).

To test hypothesis 3, we use the rating and the leverage ratio of the borrower in the reverse repo sample. The results from Table 8 show that both have significant impact. Our reporting banks charge higher-rated (lower default probability) borrowers and lower-levered banks lower haircuts: one unit increase in rating decreases the haircut by 1.7% and one standard deviation drop in leverage lowers the haircut by 7.7% (column (5)). These findings are consistent with the third hypothesis.

The results in column (5) of Tables 8–9 also show that larger counterparties are charged lower haircut by our reporting banks: one standard deviation increase in size massively reduces the haircut by 15.8% and the magnitude is even higher for the cash sample at 20.9%. This finding shows that there is significant tiering in the repo market, similar to that in other short-term funding markets (Rime et al. (2022)). The results for the repo sample are not statistically significant although the positive sign indicates that larger lenders charge a higher haircut. Counterparties with missing data on counterparty characteristics charge a higher haircut as lenders, but receive a lower haircut as borrowers (except for credit repo). The majority of these counterparties are small banks, asset managers, and some hedge funds.

Test 4 (bilateral relationship): The repo haircut is lower for bilateral parties with a stable banking relationship.

Table 11 reports the percentages of significantly negative and positive relationship fixed effects in specifications with and without bank fixed effects. It shows that an overwhelming majority of relationship fixed effects yield statistically significant negative haircuts. The reduction in haircut is around 7-10 basis points for reverse repo transactions, and 4-6 basis points for repo transactions. The results indicate that bilateral banking relationships indeed reduce the haircut.

Figure 5 presents a network graph of all the bank-counterparty relationship fixed effects, significant at the 5% (one-sided) level. Red colour means the regression coefficient on the fixed effect is negative (lower haircut if the given two nodes enter a repo contract). Blue colour means the coefficient is positive, i.e. higher haircut if the two nodes enter a contract. The thickness of the edge between two nodes shows the magnitude of the coefficient on the relationship fixed effect. The size of each node reflects the number of significant fixed effects involving the node.

The figure is consistent with the hypothesis that bilateral relationships matter in haircut determination since some entities are consistently able to borrow at a lower haircut from set of counterparties. For example, bank B both borrows from and lends to counterparties C115, C167 and C189 at a significantly lower haircut. Interestingly, the same bank also lends at zero haircut to the largest number of counterparties, and also borrows at zero haircuts from many entities as seen from Figure 4. Bank A, which is also a major zero-haircut borrower and lender, is also involved in several significant relationships as seen from Figure 5 but the bank is charged or charges also higher haircuts when interacting with a set of counterparties as indicated by the blue lines. Overall, we find evidence in support of the fifth hypothesis and show that there are important bilateral relationship in determining haircuts.[22]

Test 5 (portfolio repos): Risky assets in a portfolio repo with safe assets have lower haircut than purely risky asset repos.

To implement this test, we define a dummy equal to one if an asset is a part of portfolio which contains at least one highest-rated asset (AAA). The coefficient on the dummy for collateral bundled in a safe-asset portfolio from Table 8 shows that lower-rated assets in a portfolio with a safe asset have a lower haircut (about 60 bps) in the reverse repo sample compared to the same assets in a standalone arrangement. A more detailed analysis of the safe-asset portfolios shows that lower-rated counterparties are more likely to bundle assets in such portfolios. Hedge funds are the counterparties with the largest fraction of portfolios bundled with a safe asset. The effect of a safe asset in a portfolio is, however, not statistically significant for the repo sample and even becomes positive for credit collaterals. Overall, there is mixed evidence for this hypothesis.

[22]The bilateral relationships might stem from interactions between the two entities in markets other than the repo market. For example, a customer might also have an established trading relationship with the bank in other, non-repo assets. Examining the drivers of bilateral relationships is an interesting question that is out of the scope of this paper since we do not observe interactions beyond those in the repo market.

Test 6 (lender's quality and liquidity): The repo haircut is larger when the default probability and/or liquidity need of the lender is higher.

In the reverse repo regressions, the lenders are the reporting banks and borrowers are various counterparties. In the repo regressions, the lenders are various counterparties. Table 8 shows that none of the counterparties in the repo regressions affect the haircut except for central banks and government. In addition, none of counterparty characteristics coefficients other than that of counterparties with missing data is consistently statistically significant. The estimates on lender's cash ratio, which could be proxy for lender's liquidity needs, is insignificant. Similarly, the estimates on lender's CDS and leverage, which could proxy for default probability, are also not significant, whereas the coefficient on rating is positive but only marginally significant. These findings are not strongly supportive of hypothesis 6 and indicate that lender's default probability or liquidity need not affect how lenders set haircut in repo contracts.

5.3 Likelihood of zero-haircut repos

Given the multitude of zero haircuts in the data, we now study which transactions are more likely to get a zero haircut. To do that, we replace the independent variable with a dummy taking value 1 if the haircut is zero and value 0 otherwise: $D_{j,zero\ haircut}$. We then estimate a simple OLS (a linear probability model) where the regression coefficients on the dependent variables can be interpreted as the marginal effects on the probability of observing zero haircut on a given contract:

$$D_{j,zero\ haircut} = \beta \times determinants_j + BankFE + RelationshipFE + CurrencyFE + \varepsilon_j. \quad (11)$$

Table 12 shows that the R^2 is very high in all regressions, suggesting that the explanatory variables capture most of the variation in zero vs non-zero haircuts. A closer look shows that the relationship FEs explain the largest part of that variation. In addition, collateral quality and liquidity variables affect the probability of receiving zero haircut in a way similar to the size of haircut, which we studied earlier. Lower contract maturity and higher collateral rating increase the probability of receiving a zero haircut in the reverse repo sample. Riskier counterparties (as measured by their CDS spreads) are less likely to receive a zero haircut. We also find that the probability of a zero haircut is higher when the counterparties are broker-dealers, central banks, asset managers, or even hedge funds (a marginally significant effect in reverse repo).[23]

5.4 Determinants of CCP trades

We now examine characteristics of trades with CCP as the counterparty. In unreported regressions we use the entire sample including the CCP deals and run the main regressions. None of the results mentioned above changes significantly, with one exception. We observe that including CCP transactions attenuates the impact of counterparty concentration on increasing haircuts. Overall, given the issues described in Section 5, it seems that CCP trades are motivated by different economic considerations and including CCP transactions introduces some noise in the way that the architecture of the market affects haircuts.

In Table 13, we compare CCP versus non-CCP transactions to shed light on the different economic motivations behind these trades. One immediate observation is that when our reporting banks transact through CCPs, they earn lower intermediating spreads, since they are borrowing at a higher average repo haircut via CCPs (at 0.044) than from non-CCP counterparties (at 0.039), and lending out at a lower average reverse repo haircut via CCPs (at 0.071) compared to non-CCP counterparties (0.096). Table 13 also shows that transactions with CCPs are more likely to have zero haircut.

Trades with CCPs offer a significant advantage over non-CCP transactions because CCP trades are netted and expand banks' balance sheet less. Due to this netting benefit, banks use CCPs often for collateral management and less so for earning intermediating spreads. To see if banks are indeed utilising this netting benefit, we compute the ratio of total repo and reverse repo positions against a given counterparty from the point of view of reporting banks in our sample. Table 13 shows that the mean ratio is 1.03 for CCPs, indicating that the net position with CCPs is close to zero. By comparison, the ratio is 5.77 for non-CCP counterparties, which shows that banks engage in one-directional trades with such counterparties. This fact suggests that banks use CCPs for collateral management purposes.

Next, we study whether the probability of zero haircuts is different for CCP trades. To control for collateral-level heterogeneity, we examine whether at the contract level, the probability of zero repo and reverse repo haircuts is different depending on whether the bank trades with CCPs or non-CCP counterparty. We run the following linear probability

[23]The evidence pertaining to the role of relationships in affecting zero haircuts adds to the recent US evidence of Baklanova et al. (2019).

model:

$$D_j^{zero\ haircut} = \beta \times D_{j,CCP} + \gamma_1 \times notional_j + \gamma_2 \times maturity_j + CollateralFE + BankFE + \varepsilon_j, \quad (12)$$

where $D_{j,CCP}$ takes value 1 when the counterparty is a CCP. The results are reported in Table 14. They show that the probability of a zero haircut rises by about 17% when the reporting banks lend via CCPs relative to lending to non-CCP counterparties, but this probability is lower for transactions with large notional values.[24] The estimates on maturity show that longer-maturity trades are less likely to have zero haircut, which is consistent with collateral management for short periods. By comparison, for repo trades, whether the counterparty is a CCP or not does not affect the probability of receiving a zero haircut. This evidence also suggests that reporting banks are not motivated by earning intermediating spreads when transacting with CCPs.

Finally, we investigate the determinants of trading with a CCP. To do so, we run the following linear probability model:

$$D_{j,CCP} = \beta \times determinants_j + BankFE + \varepsilon_j. \quad (13)$$

Table 15 shows that the probability of a trade with a CCP increases in the notional of the trade, in the collateral rating, and when the transaction is denominated in GBP, EUR and USD. The probability decreases for credit collaterals, which suggests that CCP transactions are motivated by managing high quality collateral inventories of the reporting banks in our sample.[25] Together with the fact that CCP trades tend to involve high quality collaterals (See Table 2), these findings indicate that reporting banks use CCPs to reallocate high quality collaterals among themselves.

6 Conclusion

In this study, we analyse the structure of the UK bilateral repo market using a unique transaction-level dataset. We uncover features of the repo market in the UK that are dis-

[24]This might also reflect the possibilities that assets of low notional values are packaged in a collateral portfolio together with those of large notional values to back repo transactions. Therefore, haircuts are assessed on assets of large notional values to meet the initial margin requirement.

[25]A caveat of this analysis is that CCPs in our sample period did not experience stress. For an analysis of CCPs in turbulent times, see Duffie (2014) and Boissel et al. (2017).

tinct from the US market. In this unique setting, we examine how banks intermediate liquidity among different counterparties via repo trades and how they use CCPs to reallocate high quality collaterals. We analyse the characteristics of contract terms including maturity structure, collateral and counterparty types associated with these trades and test various economic mechanisms that can affect the amount of repo liquidity provided via haircuts. Beside asset quality and liquidity, we find that counterparties matter in haircut determination. The effect of counterparties is consistent with an adverse selection explanation of haircuts, but not with effects related to lenders' liquidity position or default probabilities affecting the size of haircuts. Therefore, effective policy interventions to improve repo funding conditions during times of financial market stress should target measures that mitigate adverse selection about repo collaterals.

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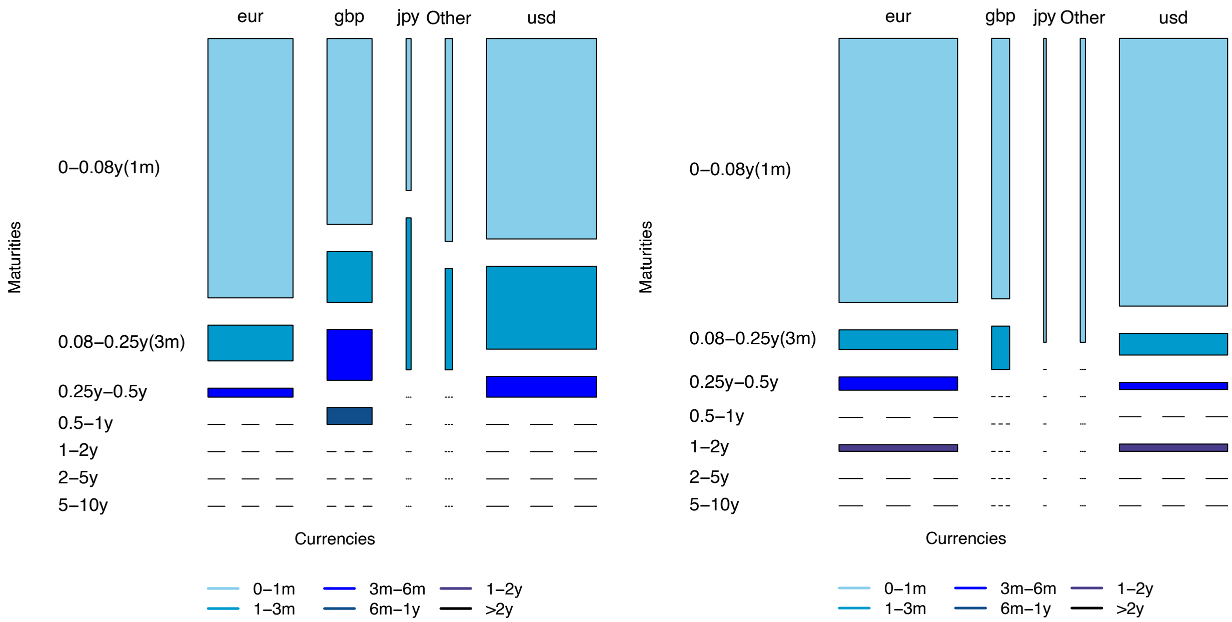
Figures

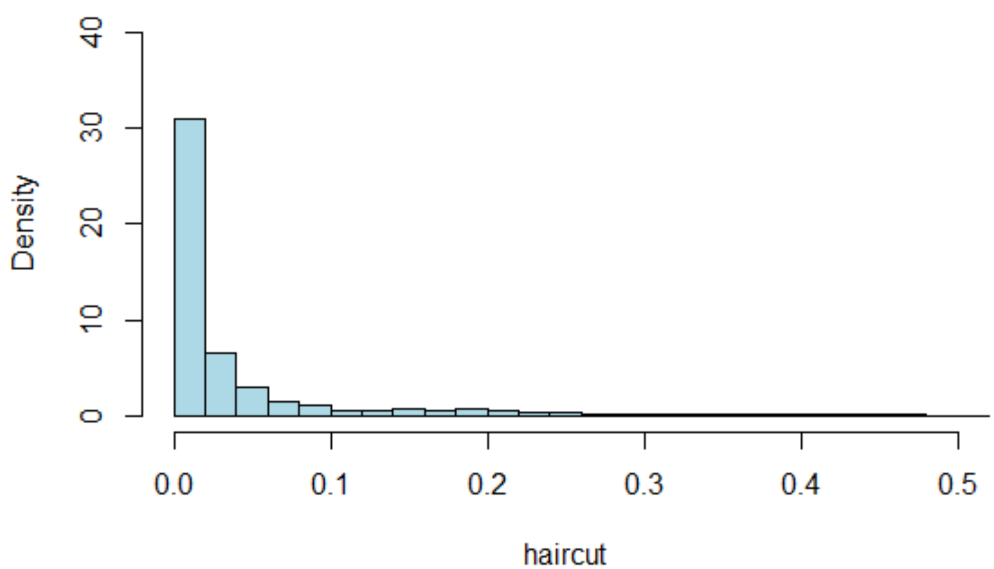
Figure 1: Currency vs. maturity of the contracts



(a) Reverse Repo (b) Repo

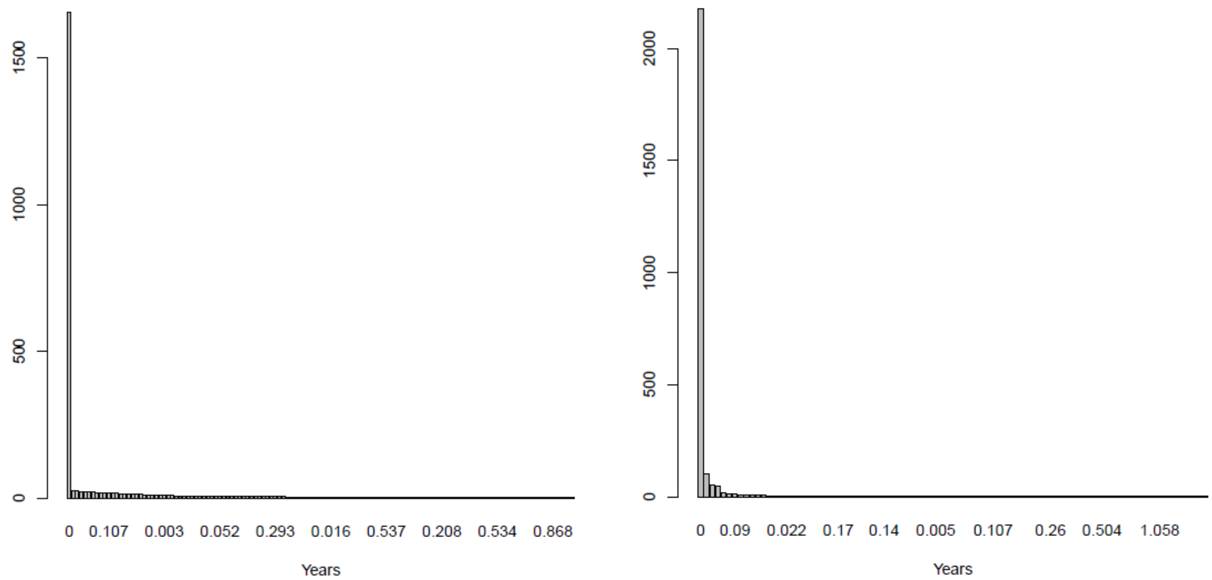
The area of each rectangle represents the fraction of contracts (in terms of frequency, not notional values) within a particular maturity-currency group. The area of the entire square is 100%.

Figure 2: Distribution of haircuts



The figure shows the density of haircuts for both Repo and Reverse Repo contracts.

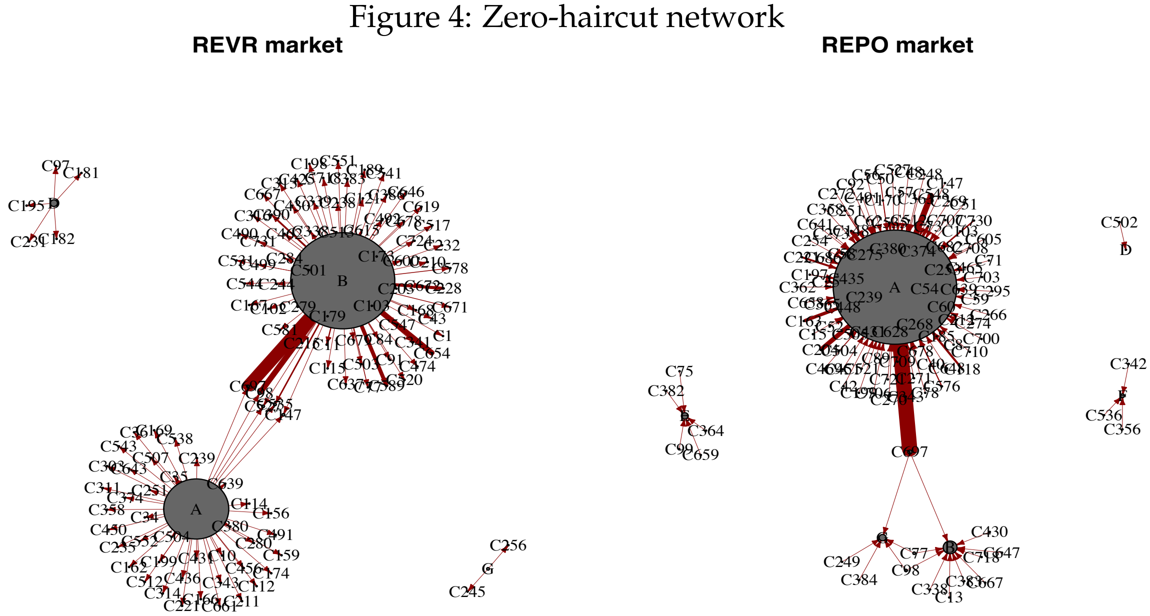
Figure 3: Maturity distribution of zero-haircut deals



(a) Reverse Repo (b) Repo

Number of zero-haircut contracts for each maturity in the zero-haircut subsample.

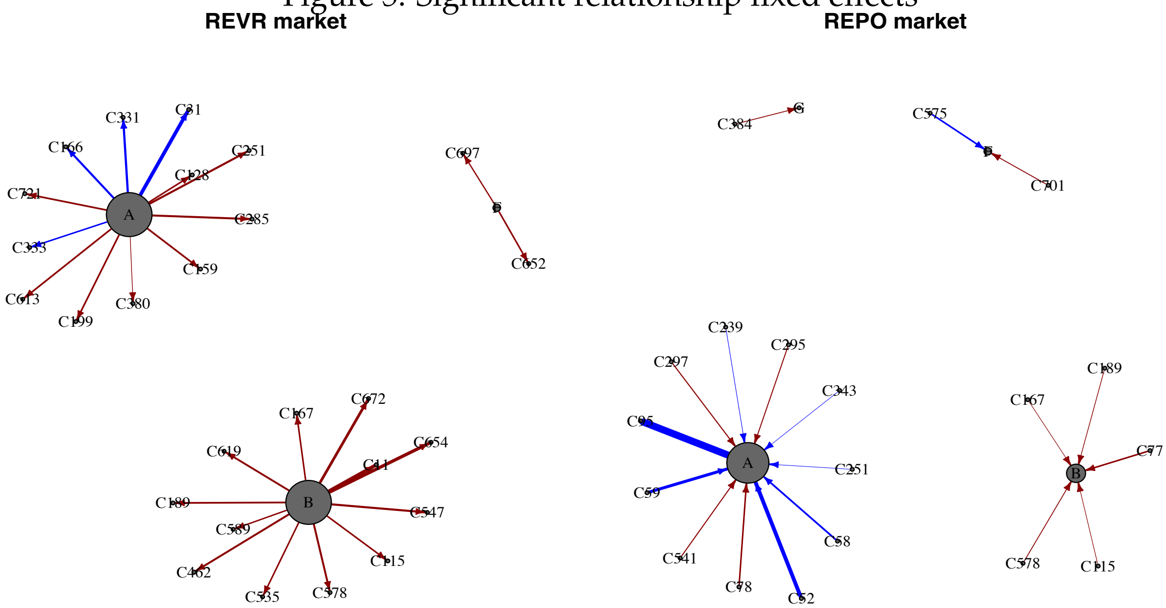
Figure 4: Zero-haircut network



(a) Reverse Repo (b) Repo

The size of each node reflects the number of counterparties with which it has at least one zero-haircut deal. Edge width is increasing in the total number of zero-haircut trades between two given nodes. A, B, D, E, F, and G denote the six reporting banks, and nodes labeled with C and numeric denote their counterparties.

Figure 5: Significant relationship fixed effects



(a) Reverse Repo.

(b) Repo.

Network graph implied by the statistically significant, at the 5% (one sided) level, relationship fixed effects for reverse repo (panel (a)) and repo (panel (b)) contracts. Estimates based on the regressions from columns 5 (reverse repo) and 10 (repo) of Table 8. A relationship is defined as having at least 10 bilateral transactions. Red (blue) arrows denote negative (positive) fixed effects while their direction represent the lending flow. Node sizes are proportional to the number of bilateral relationship fixed effects involving the given node. Edge width is increasing in the absolute magnitude of the estimate. A, B, D, E, F, and G denote the six reporting banks, and nodes labeled with C and numeric denote their counterparties.

Tables

Table 1: Breakdown of value of contracts (in bn GBP)

	REVR		REPO		
	Value	Percent	Value	Percent	Net
A. Maturity					
Overnight	29.7	12.2%	-38.1	14.3%	-8.5
1 day-3m	140.7	57.6%	-130.7	48.9%	10.0
3m-1y	65.8	26.9%	-78.1	29.2%	-12.3
1y-5y	8.0	3.3%	-18.5	6.9%	-10.5
5y+	0.0	0.0%	-1.7	0.6%	-1.6
Total	244.2	100.0%	-267.0	100.0%	-22.8
B. Currency					
GBP	110.2	45.1%	-149.8	56.1%	-39.6
EUR	90.6	37.1%	-86.7	32.5%	4.0
USD	30.5	12.5%	-26.8	10.0%	3.7
JPY	6.0	2.5%	-1.6	0.6%	4.4
Other	6.9	2.8%	-2.1	0.8%	4.8
Total	244.2	100.0%	-267.0	100.0%	-22.8
C. Counterparty type					
Another reporting bank [a]	8.2	3.4%	-10.2	3.8%	-2.0
Other banks	29.3	12.0%	-43.6	16.3%	-14.3
Broker-dealer [b]	15.0	6.1%	-15.8	5.9%	-0.8
Hedge fund	15.1	6.2%	-15.5	5.8%	-0.4
MMFs	0.0	0.0%	-1.9	0.7%	-1.9
Other asset managers [c]	11.5	4.7%	-8.3	3.1%	3.2
CCP	145.5	59.6%	-131.3	49.3%	14.2
Insurance and pension	9.5	3.9%	-8.5	3.2%	1.0
Central bank and government	5.5	2.3%	-28.6	10.7%	-23.0
Other [d]	4.4	1.8%	-2.8	1.0%	1.6
Total	244.1	100.0%	-266.6	100.0%	-22.5
D. Collateral type					
US govt	10.9	6.0%	-5.4	2.9%	5.5
UK govt	83.1	45.8%	-111.7	59.1%	-28.6
Germany govt	25.5	14.0%	-19.1	10.1%	6.4
France govt	16.9	9.3%	-7.2	3.8%	9.7
GIIPS [e]	4.1	2.2%	-4.4	2.3%	-0.3
Other sovereign	31.6	17.4%	-16.0	8.4%	15.7
Corporate debt	7.5	4.1%	-11.7	6.2%	-4.2
Securitisation	2.0	1.1%	-13.5	7.1%	-11.5
Other	0.0	0.0%	0.0	0.0%	0.0
Total	181.6	100.0%	-188.9	100.0%	-7.3

Breakdown of deals by maturity, currency, counterparty, and collateral (Panels A, B, C, and D respectively). Value of the trades is in billion (bn) GBP. The total values in Panels A, B, C and D are based on data from six reporting banks that report haircut and collateral information. Discrepancies in row Total are due to missing information.
[a] The reporting banks report on a UK-consolidated basis, but counterparties are reported on a global basis. Therefore, there may be discrepancies between the reverse repos and repos with the reporting banks. [b] Broker-dealers are mostly securities firms that are subsidiaries of large banks. [c] Non-leveraged non-MMF mutual funds—asset managers that are not hedge fund or MMF. [d] Includes corporations, schools, hospitals and other non-profit organizations. [e] Greece, Italy, Ireland, Portugal, and Spain government bonds.

Table 2: Breakdown of value of contracts with CCPs (in bn GBP)

	REVR		REPO		
	Value	Percent	Value	Percent	Net
A. Maturity					
Overnight	5.5	3.9%	-5.1	3.9%	0.4
1 day-3m	88.0	62.1%	-71.7	54.6%	16.3
3m-1y	42.2	29.8%	-50.5	38.4%	-8.3
1y-5y	6.0	4.2%	-4.0	3.1%	2.0
Total	141.7	100.0%	-131.3	100.0%	10.4
B. Currency					
GBP	80.2	56.6%	-108.5	82.6%	-28.3
EUR	59.2	41.8%	-21.3	16.2%	37.9
USD	2.4	1.7%	-1.5	1.1%	0.9
Other	0.0	0.0%	0.0	0.0%	0.0
Total	141.7	100.00%	-131.3	100.00%	10.4
C. Collateral type					
UK govt	65.5	59.0%	-93.8	86.7%	-28.3
Germany govt	20.1	18.1%	-6.2	5.7%	13.9
France govt	12.1	10.9%	-2.5	2.3%	9.6
GIIPS [a]	0.2	0.2%	-0.5	0.5%	-0.3
Other sovereign	12.7	11.4%	-5.2	4.8%	7.5
Corporate debt	0.5	0.5%	0.0	0.0%	0.5
Securitisation	0.1	0.0%	0.0	0.0%	0.0
Total	111.1	100.0%	-108.2	100.0%	2.8

Breakdown of the deals involving CCPs by maturity, currency, and collateral type (Panels A, B, C respectively). Value of the trades is in bn GBP. Total values in Panels A, B and C are based on data from six reporting banks that report haircut and collateral information. Discrepancies in row Total are due to missing information.

[a] Greece, Italy, Ireland, Portugal, and Spain government bonds.

Table 3: Breakdown of value of 'clearly cash' and 'clearly credit' contracts (in bn GBP)

	Clearly Credit					Clearly Cash				
	REVR		REPO			REVR		REPO		
	Value	%	Value	%	Net	Value	%	Value	%	Net
A. Maturity										
Overnight	4.8	50.3%	-7.2	28.6%	-2.4	8.4	5.50%	-10.9	7.20%	-2.5
1 day-3m	3.4	35.4%	-0.9	3.4%	2.5	89.8	58.2%	-80.6	53.3%	9.1
3m-1y	1.4	14.4%	-4.9	19.4%	-3.5	50	32.4%	-53.6	35.4%	-3.6
1y-5y	0.0	0.0%	-10.9	43.3%	-10.9	6.1	3.9%	-6	4.0%	0.1
5y+	0.0	0.0%	-1.3	5.3%	-1.3	0	0.0%	-0.2	0.1%	-0.2
Total	9.5	100.0%	-25.2	100.0%	-15.7	154.2	100.00%	-151.3	100.0%	2.9
B. Currency										
GBP	0.9	9.8%	-5.6	22.4%	-4.7	83.2	53.9%	-111.3	73.6%	-28.1
EUR	3.3	34.6%	-11.7	46.5%	-8.4	53.8	34.9%	-30.8	20.3%	23.0
USD	5.3	55.5%	-8.1	32.1%	-2.8	13.2	8.6%	-8.3	5.5%	5.0
JPY	0.0	0.0%	0.0	0.2%	0.0	4.0	2.6%	-1.0	0.6%	3.0
Other	0.0	0.1%	0.3	-1.1%	0.3	0.0	0.0%	0.0	0.0%	0.0
Total	9.5	100.0%	-25.2	100.0%	-15.7	154.2	100.0%	-151.3	100.0%	2.9
C. Counterparty										
Reporting bank[a]	1.0	10.9%	-3.8	15.0%	-2.7	4.5	3.0%	-0.8	0.6%	3.7
Other banks	2.3	23.8%	-9.1	35.9%	-6.8	8.2	5.4%	-13.0	8.6%	-4.8
Broker-dealer [b]	2.1	21.8%	-6.3	25.1%	-4.3	5.5	3.7%	-2.1	1.4%	3.5
Hedge fund	1.7	17.7%	-0.7	2.7%	1.0	1.9	1.3%	-5.1	3.4%	-3.2
MMFs	0.0	0.0%	0.0	0.0%	0.0	0.0	0.0%	-1.9	1.3%	-1.9
Other ass. mng.[c]	0.5	4.8%	-1.6	6.4%	-1.1	9.2	6.1%	-4.3	2.9%	4.9
CCP	0.6	5.9%	0.0	0.1%	0.5	109.3	72.7%	-105.9	70.1%	3.4
Insur. & pens.	0.7	7.6%	-3.1	12.2%	-2.4	5.1	3.4%	-1.7	1.1%	3.4
CB & gov.	0.1	0.8%	-0.6	2.5%	-0.6	3.5	2.3%	-15.1	10.0%	-11.6
Other[d]	0.6	6.7%	0.0	0.1%	0.6	3.2	2.1%	-1.1	0.7%	2.0
Total	9.5	100.0%	-25.2	100.0%	-15.7	150.3	100.0%	-151.0	100.0%	-0.7

Breakdown of 'clearly cash' and 'clearly credit" Repo and Reverse Repo deals by maturity, currency, and counterparty (Panels A, B, C respectively). Clearly cash repos are those using government bonds from the UK, the US, Germany, France, Japan, France, Belgium, the Netherlands and Austria. Clearly credit repos are those using corporate bonds or securitized products. Value of the trades is in bn GBP. Total values in Panels A, B and C are based on data from six reporting banks that report haircut and collateral information. Discrepancies in row Total are due to missing information. This table omits the medium quality subsample.

[a] The reporting banks report on a UK-consolidated basis, but counterparties are reported on a global basis. Therefore, there may be discrepancies between the reverse repos and repos with the reporting banks.

[b] Broker-dealers are mostly securities firms that are subsidiaries of large banks. [c] Non-leveraged non-MMF mutual funds—asset managers that are not hedge fund or MMF. [d] Includes corporations, schools, hospitals and other non-profit organizations.

Table 4: Rehypothecation Rate of Assets

	<5Y	5-10Y	10-20Y	>20Y<
Total	28.8%	33.3%	41.3%	36.2%
Cash	29.7%	47.6%	56.3%	24.9%
Credit	27.6%	23.9%	16.6%	8.3%

Rehypothecation rates computed at the CUSIP/ISIN-level as the total amount of collateral asset posted (via repo) divided by the total amount received (via reverse repo).

Table 5: Breakdown of haircuts for the non-CCP subsample

	Average haircut		Zero haircut % of notional	
	REVR	REPO	REVR	REPO
A. Maturity				
Overnight	1.9%	0.7%	42.2%	78.9%
1 day-3m	3.2%	1.4%	47.5%	15.0%
3m-1y	0.6%	0.5%	10.3%	5.3%
1-5y	0.0%	0.7%	0.0%	0.8%
5y+	0.0%	0.0%	0.0%	0.0%
B. Currency				
GBP	1.4%	0.8%	35.9 %	9.0 %
EUR	1.5%	1.4%	31.7 %	50.7 %
USD	2.6%	0.9%	24.4 %	36.1 %
JPY	0.1%	0.0%	4.2 %	2.1 %
Other	0.2%	0.1%	3.8 %	2.1 %
C. Counterparty type				
Another reporting bank [a]	0.1%	0.2%	4.3 %	4.8 %
Other banks	1.9%	1.4%	41.7 %	62.5 %
Broker-dealer [b]	0.9%	0.6%	8.3 %	10.2 %
Hedge fund	1.4%	0.1%	1.4 %	0.0 %
Other asset managers [c]	1.0%	0.1%	10.5 %	13.3 %
Insurance and pension	0.3%	0.5%	15.6 %	1.2 %
Central bank and government	0.0%	0.3%	6.6 %	7.3 %
Other [d]	0.3%	0.0%	11.5 %	0.8 %
D. Collateral type				
US govt	0.4%	0.0%	6.0 %	0.3 %
UK govt	1.0%	0.4%	24.5 %	1.5 %
Germany govt	0.1%	0.1%	8.7 %	17.3 %
France govt	0.1%	0.1%	3.4 %	7.9 %
GIIPS [e]	0.2%	0.1%	1.1 %	2.1 %
Other sovereign	1.1%	0.2%	19.2 %	30.4 %
Corporate debt	1.1%	0.6%	36.8 %	30.7 %
Securitisation	0.5%	0.8%	0.3 %	9.8 %
Other	0.0%	–	0.0%	–
Overall average	1.2%	0.7%		

The table presents the breakdown of the deals by maturity, currency, counterparty type, and collateral type (Panels A, B, C, and D, respectively). For each category, it shows the average haircut (columns 2 and 3), as well as distribution of zero haircut deals (columns 4 and 5), for the reverse repos and repos, respectively. The averages are weighted by the gross notional of the transactions. The haircuts are based on the data from the six banks that report haircut and collateral information (excluding deals with CCPs).
[a] The reporting banks report on a UK-consolidated basis, but counterparties are reported on a global basis. Therefore, there may be discrepancies between the reverse repos and repos with the reporting banks.
[b] Broker-dealers are mostly securities firms that are subsidiaries of large banks. [c] Non-leveraged non-MMF mutual funds—asset managers that are not hedge fund or MMF. [d] Includes corporations, schools, hospitals and other non-profit organizations. [e] Greece, Italy, Ireland, Portugal, and Spain government bonds.

Table 6: Summary statistics for the sample excluding deals with CCPs

Variable	Obs	Mean	Std dev	Min	Max	Average [a]
A. REVR						
Haircut	8754	6.25%	10.13%	0.00%	46.15%	6.15%
Notional	10435	6.25	0.86	3.45	8.32	6.25
Maturity	10435	0.07	0.14	0.00	3.00	0.06
Collateral maturity	7085	11.88	10.42	0.22	43.18	12.01
Collateral rating	5729	14.54	4.83	3.00	20.00	14.60
Ctpy size	6512	5.17	0.70	3.57	6.25	5.16
Ctpy RoA	6506	0.29	0.41	-1.26	1.98	0.29
Ctpy leverage	6469	5.56	1.33	2.97	11.00	5.56
Ctpy CDS	5593	0.01	0.01	0.01	0.04	0.01
Ctpy cash ratio	6484	-0.01	5.48	-81.44	4.37	-0.03
Ctpy rating	6495	14.59	1.28	8.00	20.00	14.60
VaR	5875	1.89	1.31	0	7.01	1.87
B. REPO						
Haircut	7386	2.37%	5.82%	0.00%	46.15%	2.36%
Notional	11896	6.18	0.79	3.45	8.32	6.21
Maturity	11905	0.08	0.35	0.00	3.00	0.08
Collateral maturity	8993	7.50	7.81	0.22	43.18	7.50
Collateral rating	8629	14.34	4.99	3.00	20.00	14.33
Ctpy size	8380	5.37	0.62	3.57	6.25	5.37
Ctpy RoA	8367	0.36	0.39	-1.26	1.98	0.36
Ctpy leverage	7300	5.87	1.42	2.97	11.00	5.86
Ctpy CDS	5908	0.02	0.01	0.01	0.04	0.02
Ctpy cash ratio	8160	0.01	6.63	-81.44	4.37	0.01
Ctpy rating	8445	15.19	1.94	8.00	20.00	15.19
VaR	5579	1.74	1.2	0	7.01	1.74

The table shows the summary statistics of variables used in the regressions excluding the deals with CCPs, for repo and reverse repo transactions. The sample only includes the six banks that provided data on haircuts and collateral. Variables have been winsorized at 0.5% level. Rating scale is 1–20, with 20 being the highest rating.
[a] Average is weighted by the gross notional of transactions.

Table 7: Summary statistics for the 'clearly cash' and 'clearly credit' samples (excluding deals with CCPs or with medium quality collaterals)

	Clearly Cash						Clearly Credit					
Variable	Obs	Mean	S.d.	Min	Max	Av. [a]	Obs	Mean	S.d.	Min	Max	Av. [a]
A. REVR												
Haircut	1188	5.03%	8.12%	0.00%	39.70%	5.21%	2878	7.92%	13.07%	0.00%	47.47%	7.89%
Notional	1233	7.16	0.67	4.49	8.54	7.17	3558	6.01	0.54	4.16	7.81	6.01
Maturity	1233	0.21	0.20	0.00	1.01	0.21	3558	0.04	0.11	0.00	1.50	0.04
Col. mat.	1233	13.87	12.13	0.22	49.44	13.89	3479	9.66	9.74	0.21	40.07	9.68
Col. rating	969	19.68	0.84	16.81	20.00	19.68	3322	13.26	4.30	4.00	20.00	13.27
Ctpy size	410	5.6	0.73	3.70	6.24	5.59	2094	5.30	0.62	3.57	6.24	5.30
Ctpy RoA	410	0.34	0.54	-1.01	1.60	0.34	2108	0.15	0.32	-1.21	1.55	0.15
Ctpy leverage	407	6.06	0.96	3.73	9.09	6.08	2093	5.37	1.33	3.19	9.42	5.37
Ctpy CDS	324	0.02	0.01	0.01	0.03	0.02	1826	0.01	0.00	0.01	0.04	0.01
Ctpy cash ratio	410	0.51	0.79	0.01	12.60	0.51	2098	0.36	0.46	0.01	4.59	0.36
Ctpy rating	410	14.23	1.23	3.00	16.00	14.24	2094	14.57	1.10	9.00	20.00	14.57
VaR	1230	2.21	1.62	0.03	6.66	2.21	3207	1.86	1.28	0	7.92	1.86
B. REPO												
Haircut	517	3.13%	7.89%	0.00%	39.70%	3.04%	3317	2.52%	6.54%	0.00%	47.47%	2.46%
Notional	713	7.21	0.86	4.49	8.54	7.21	5838	5.96	0.59	4.16	7.89	5.96
Maturity	713	0.15	0.26	0.00	1.01	0.15	5839	0.11	0.49	0.00	3.65	0.10
Col. mat.	713	10.65	9.78	0.22	49.44	10.69	5692	6.99	7.58	0.21	40.07	7.00
Col. rating	594	19.86	0.53	17.00	20.00	19.86	5498	13.18	4.59	4.00	20.00	13.17
Ctpy size	268	5.23	0.64	3.70	6.24	5.23	4212	5.45	0.54	3.57	6.25	5.45
Ctpy RoA	268	0.49	0.39	-1.01	1.65	0.50	4203	0.33	0.35	-1.21	1.55	0.33
Ctpy leverage	258	6.43	1.22	2.97	9.09	6.41	3490	5.89	1.47	3.19	9.42	5.89
Ctpy CDS	136	0.02	0.01	0.01	0.06	0.02	2780	0.02	0.01	0.01	0.04	0.02
Ctpy cash ratio	266	1.07	1.98	0.01	12.6	1.06	4103	0.63	0.89	0.01	4.59	0.63
Ctpy rating	266	14.62	2.14	3.00	17.00	14.62	4277	15.48	1.91	9.00	20.00	15.49
VaR	600	1.85	1.31	0.04	6.25	1.86	3313	1.75	1.22	0	7.92	1.74

The table shows the summary statistics of variables used in the regressions excluding the deals with CCPs, for repo and reverse repo transactions across the 'clearly cash' and 'clearly credit' subsamples excluding the medium quality collateral subsample. 'Clearly cash' repos are those using government bonds from the UK, the US, Germany, France, Japan, France, Belgium, the Netherlands and Austria. 'Clearly credit' repos are those using corporate bonds or securitized products. Variables have been winsorized at 0.5% level. Rating scale is 1–20, with 20 being the highest rating.

[a] Average is weighted by the gross notional of transactions.

Table 8: The drivers of haircuts (excluding deals with CCPs)

	Reverse Repo					Repo				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Deal vars:										
notional	-0.013**	-0.002	-0.002	-0.004	-0.003	0.003	0.002	0.001	0.001	0.001
maturity	0.070**	0.072**	0.066**	0.041	0.054*	0.029**	0.031***	0.033***	0.034***	0.035***
Collateral vars:										
collrating		-0.009***	-0.008***	-0.007***	-0.012***		-0.000	-0.001	-0.001	0.000
collmaturity		0.000	0.000	0.000	0.004		0.002*	0.002	0.002	0.002*
securitisation		0.017	0.029*	0.023	0.019		-0.000	0.001	0.001	0.002
var		0.006*	0.005*	0.006**	0.005**		0.011**	0.010**	0.010**	0.010**
asset in safe portf		-0.004	-0.006*	-0.005*	-0.006*		0.002	0.001	0.002	0.002
Cpty type:										
brokerdealers			-0.017	-0.003	0.004			0.002	0.004	0.005
hedgefund			0.114***	0.085***	0.072**			0.003	0.008	0.013
otherassetmanagers			0.035*	0.026	0.024			0.011	0.016	0.014
insurance&pension			0.006	-0.021	-0.003			0.001	0.004	-0.000
centralbank&government			-0.007	-0.006	0.009			0.048**	0.053***	0.049**
other			0.083*	0.055	0.044			0.003	0.003	0.000
Cpty vars:										
cptysize				-0.141**	-0.158**				0.039	0.029
cptyroa				-0.012*	-0.011*				-0.005*	-0.003
cptyrating				-0.003	-0.017***				0.003	0.006*
cptyleverage				0.081***	0.077***				0.011	0.005
cptycds				0.005	0.000				0.001	0.001
cptycashratio				0.011	0.016**				-0.001	-0.001
nocptydata				-0.137	-0.238*				0.143*	0.120*
Misc:										
cptycon					0.009					0.009**
collcon					0.007**					0.005**
cptyandcollrating					0.001***					-0.000*
N	3907	3907	3907	3907	3907	2915	2915	2915	2915	2915
R^2_{adj}	0.539	0.606	0.634	0.645	0.669	0.511	0.521	0.526	0.527	0.532

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

OLS regressions (equation (9)) for reverse repo, columns (1)-(5), and repo, columns (6)-(10), excluding deals with CCPs. The dependent variable is haircut and explanatory variables are listed in the first column. All quantitative variables (notional, maturity, collmaturity, VaR, cptysize, cptyroa, cptyleverage, cptycds, cptycashratio, cptycon, collcon) are standardized. All regressions include bank, relationship, and currency fixed effects. Standard errors are clustered at the counterparty level.

Table 9: 'Clearly Cash' vs 'Clearly Credit' Reverse Repo haircut drivers (excluding deals with CCPs or with medium quality collaterals)

	Clearly Cash (baseline effect, γ)					Clearly Credit (marginal effect, β)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Deal vars:										
notional	0.015**	0.013**	0.008*	0.001	0.002	-0.032***	-0.023***	-0.013**	-0.008	-0.009
maturity	0.135***	0.098***	0.078***	0.072***	0.069***	-0.146**	-0.088	-0.042	-0.063	-0.056
Collateral vars:										
collrating		0.014	0.005	0.006	0.019*		-0.019**	-0.007	-0.008	-0.022**
collmaturity		0.005	0.007	0.006	0.005		-0.010	-0.010	-0.008	-0.007
var		0.027**	0.022**	0.024**	0.025**		-0.015	-0.017	-0.018	-0.020
asset in safe portf		-0.009*	-0.005	-0.004	-0.004		0.009	0.002	0.001	0.001
Cpty type:										
brokerdealers			-0.019	-0.022	-0.022			0.030	0.048	0.046
hedgefund			-0.064***	-0.085***	-0.085***			0.286***	0.286***	0.276***
otherassetmanagers			0.007	0.003	0.004			0.011	-0.004	-0.016
insurance&pension			-0.061***	-0.080***	-0.078***			0.043**	0.044*	0.047*
centralbank&government			-0.041	-0.060**	-0.064***			-0.003	0.048	0.054
other			0.081	0.055	0.046			0.080*	0.080*	0.079*
Cpty vars:										
cptysize				-0.187***	-0.209***				0.083	0.082
cptyroa				0.000	0.003				-0.015	-0.017
cptyrating				0.007	0.034**				-0.008	-0.038**
cptyleverage				-0.033	-0.028				0.094*	0.085
cptycds				-0.004	-0.007				0.012	0.015
cptycashratio				0.047***	0.047***				-0.039***	-0.038***
nocptydata				-0.407**	-0.469***				0.321	0.325
Misc:										
cptycon					-0.015					0.021**
collcon					0.012*					0.115
cptyandcollrating					-0.002**					0.002***
N	3059	3059	3059	3059	3059					
R^2_{adj}	0.657	0.693	0.778	0.783	0.785					

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

OLS regressions for the 'clearly cash' and the 'clearly credit' reverse repo subsamples excluding deals with CCPs (equation (10)). 'Clearly cash' contracts are those using government bonds from the UK, the US, Germany, France, Japan, France, Belgium, the Netherlands and Austria. Clearly credit contracts are those using corporate bonds or securitized products. The dependent variable is haircut and explanatory variables are listed in the first column. Columns (1)-(5) capture the baseline – corresponding to the clearly cash sample – effects, while columns (6)-(10) capture the marginal effect of the clearly credit sample compared to the clearly cash sample. All quantitative variables (notional, maturity, collmaturity, VaR, cptysize, cptyroa, cptyleverage, cptycds, cptycashratio, cptycon, collcon) are standardized. All regressions include bank, relationship, and currency fixed effects. Standard errors are clustered at the counterparty level.

Table 10: 'Clearly cash' vs 'Clearly credit' Repo haircut drivers (excluding deals with CCPs or with medium quality collaterals)

	Clearly Cash (baseline effect, γ)					Clearly Credit (marginal effect, β)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Deal vars:										
notional	0.002	0.002	-0.000	-0.001	-0.001	0.001	-0.001	0.002	0.003	0.004
maturity	0.002	-0.004	-0.000	-0.008	-0.009	0.030	0.040	0.036	0.049**	0.051**
Collateral vars:										
collrating		-0.004	-0.005	-0.014	0.002		0.003	0.004	0.013	-0.001
collmaturity		0.006	0.003	0.002	0.004		-0.003	-0.001	0.000	-0.001
var		0.017	0.022	0.020	0.016		-0.003	-0.007	-0.006	-0.002
asset in safe portf		-0.008	-0.009*	-0.008*	-0.007		0.011*	0.012*	0.011*	0.011*
Cpty type:										
brokerdealers			-0.008	0.012	0.011			0.010	-0.015	-0.015
hedgefund			0.000	0.000	0.000			0.000	0.000	0.000
otherassetmanagers			0.007	0.027*	0.028*			0.008	-0.006	-0.006
insurance&pension			-0.005	0.016	0.015			0.000	0.000	0.000
centralbank&government			0.039*	0.057***	0.055***			0.000	0.000	0.000
other			-0.006	0.012	0.010			0.024	-0.002	0.001
Cpty vars:										
cptysize				0.170	0.260				-0.126	-0.248
cptyroa				0.003	0.049*				-0.011	-0.056*
cptyrating				-0.017	0.077***				0.009	-0.077***
cptyleverage				0.308**	0.637***				-0.315**	-0.649***
cptycds				0.008	0.024				-0.018	-0.031
cptycashratio				-0.014	0.016				0.014	-0.016
nocptydata				0.789**	1.113***				-0.838**	-1.167***
Misc:										
cptycon					0.056					-0.039
collcon					-0.009					0.044**
cptyandcollrating					-0.007**					0.007**
N	1995	1995	1995	1995	1995					
R^2_{adj}	0.544	0.567	0.570	0.579	0.588					

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

OLS regressions for the clearly cash and the clearly credit repo subsamples excluding deals with CCPs (equation (10)). Clearly cash contracts are those using government bonds from the UK, the US, Germany, France, Japan, France, Belgium, the Netherlands and Austria. Clearly credit contracts are those using corporate bonds or securitized products. The dependent variable is haircut and explanatory variables are listed in the first column. Columns (1)-(5) capture the baseline – corresponding to the cash sample – effects, while columns (6)-(10) capture the marginal effect of the clearly credit sample compared to the clearly cash sample. All quantitative variables (notional, maturity, collmaturity, VaR, cptysize, cptyroa, cptyleverage, cptycds, cptycashratio, cptycon, collcon) are standardized. All regressions include bank, relationship, and currency fixed effects. Standard errors are clustered at the counterparty level.

Table 11: The role of bilateral relationships

Significance level	With Bank FE negative %	With Bank FE cond. mean of neg. (bps)	With Bank FE positive %	Without Bank FE negative %	Without Bank FE cond. mean of neg. (bps)	Without Bank FE positive %
Panel A: Reverse Repo						
10%	40.3%	-7.5	9.0%	44.8%	-9.9	22.4%
5%	32.8%	-7.9	6.0%	43.3%	-10.1	17.9%
Panel B: Repo						
10%	27.9%	-3.9	23.3%	55.8%	-5.4	25.6%
5%	25.6%	-4.1	18.6%	51.2%	-5.8	23.3%

The table reports the share of significantly negative and positive relationship fixed effects for different significance levels reported in the first column, for a specification with (columns two to four) and without (columns five to seven) reporting bank fixed effects. The specification with bank fixed effects is from columns 5 and 10 of Table 8, whereas the specification without is based on the same regressions but excluding bank FEs. The conditional means (columns three and six) are the average of the significantly negative fixed effects.

Table 12: The probability of zero haircuts (excluding deals with CCPs)

	Reverse Repo					Repo				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Deal vars:										
notional	-0.003	-0.011	-0.012	-0.010	-0.010	0.001	0.002	0.004	0.004	0.005
maturity	-0.139***	-0.156***	-0.169***	-0.137***	-0.148***	-0.023	-0.031	-0.039	-0.044	-0.050
Collateral vars:										
collrating		0.006***	0.006***	0.006***	0.007***		0.004	0.005	0.005	0.004
collmaturity		0.011***	0.010***	0.009***	0.008***		-0.015**	-0.012*	-0.012*	-0.011*
securitisation		0.014	0.009	0.019	0.018		-0.072**	-0.074**	-0.074**	-0.079**
var		0.000	0.000	-0.000	0.001		-0.022	-0.009	-0.009	-0.009
asset in safe portf		-0.012	-0.013	-0.015*	-0.014*		0.009	0.011	0.011	0.009
Cpty type:										
brokerdealers			0.058*	0.050	0.049			0.152**	0.189**	0.185**
hedgefund			0.027	0.069	0.077*			0.040	0.070	0.065
otherassetmanagers			0.040*	0.056	0.060*			-0.150	-0.119	-0.115
insurance&pension			0.060	0.099*	0.104*			-0.481***	-0.441***	-0.437***
centralbank&government			0.110***	0.086	0.089*			-0.059	-0.022	-0.016
other			0.107**	0.148***	0.157***			-0.066	-0.028	-0.023
Cpty vars:										
cptysize				0.260	0.299*				-0.203	-0.165
cptyroa				-0.005	-0.006				-0.006	-0.007
cptyrating				0.007	0.007				0.037	0.034
cptyleverage				-0.134	-0.137				0.134	0.139
cptycds				-0.039***	-0.039***				0.030	0.033
cptycashratio				-0.029	-0.030*				-0.021	-0.018
nocptydata				0.278	0.324				0.436	0.528
Misc:										
cptycon					-0.024**					-0.013
collcon					-0.007					-0.029**
cptyandcollrating					-0.000					0.000
N	3907	3907	3907	3907	3907	2915	2915	2915	2915	2915
R^2_{adj}	0.910	0.912	0.913	0.915	0.915	0.663	0.667	0.679	0.681	0.684

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Linear probability model for zero haircuts in reverse repo, columns (1)-(5), and repo, columns (6)-(10), deals (excluding deals with CCPs). The dependent variable is a dummy taking value 1 if the haircut is zero and value 0 otherwise: see equation (11). Explanatory variables are listed in the first column. All quantitative variables (notional, maturity, collmaturity, VaR, cptysize, cptyroa, cptyleverage, cptycds, cptycashratio, cptycon, collcon) are standardized. All regressions include bank, relationship, and currency fixed effects. Standard errors are clustered at the counterparty level.

Table 13: CCP versus non-CCP trades

	Mean $\frac{\textit{Repo Position}}{\textit{Reverse Repo Position}}$	Mean REVR haircut	Mean REPO haircut	% of zero haircuts
Non-CCP counterparties	5.77	0.096	0.039	0.300
CCP counterparties	1.03	0.071	0.044	0.359

Summary statistics of contracts with and without CCP as a counterparty.

Table 14: Probability of zero haircuts and CCP trades

	(1) REVR	(2) REPO
$D_{j,CCP}$	0.168***	0.026
$notional_j$	-0.015**	0.001
$maturity_j$	-0.196**	-0.121**
N	5048	8258
R^2_{adj}	0.409	0.275

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Linear probability model estimation of zero haircut trades: equation (12). The specifications include reporting banks and collateral fixed effects. The dependent variable equals one 1 if the trade has zero haircut, and $D_{j,CCP}$ is a dummy variable equal to one 1 if the trade involves a CCP. Standard errors are clustered at the counterparty level.

Table 15: Determinants of trading with CCPs

	(1) REVR	(2) REPO
notional	0.100***	0.041*
maturity	-0.161	-0.072
collrating	0.017**	0.006
collmaturity	-0.004	0.015
corpdebt	-0.231***	-0.198**
securitisation	-0.303***	-0.260**
gbp	0.219***	0.221***
eur	0.286***	0.117
usd	0.092*	0.014
jpy	-0.376***	-0.127**
N	6959	10074
R^2_{adj}	0.549	0.384

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Linear probability model estimation of trades with a CCP. The dependent variable takes value 1 if the trade involves a CCP: equation (13). Standard errors are clustered at the counterparty level.

7 Appendix

Table A.1: Description of the explanatory variables

Variable	Description
gbp	Dummy variable = 1 if transaction is in GBP.
eur	Dummy variable = 1 if transaction is in EUR.
jpy	Dummy variable = 1 if transaction is in JPY.
othercurrency	Dummy variable = 1 if transaction is not GBP, EUR or JPY.
notional	Log notional of the transaction in millions GBP.
maturity	Maturity of the transaction in years.
collrating	Rating of the collateral: 20 is highest and 1 is lowest.
collmaturity	Maturity of the collateral in years.
corpdebt	Dummy variable = 1 if collateral is corporate bond.
securitization	Dummy variable = 1 if collateral is securitisation.
var	Historical 5-day, 5% Value-at-Risk of the asset.
asset in safe portf	Dummy variable = 1 if the asset is in a portfolio with at least one asset rated AAA.
brokerdealers	Dummy variable = 1 if counterparty is a broker-dealer.
hedgefund	Dummy variable = 1 if counterparty is hedge fund.
otherassetmanagers	Dummy variable = 1 if counterparty is other asset managers.
insurance&pension	Dummy variable = 1 if counterparty is insurance company or pension fund.
centralbank&government	Dummy variable = 1 if counterparty is central bank or government.
other	Dummy variable = 1 if counterparty is other type.
cptysize	Log size of the counterparty in millions GBP.
cptyroa	RoA of the counterparty.
cptyrating	Rating of the counterparty: 20 is highest and 1 is lowest.
cptyleverage	Leverage ratio of the counterparty (RWA over equity).
cptycds	CDS spread of the counterparty.
cptycashratio	Cash ratio of the counterparty (cash over short-term debt).
nocptydata	Dummy variable = 1 there is no counterparty data.
cptycon	Concentration of the counterparty measured by the share of transactions with that counterparty in total: higher number indicates more concentration.
collcon	Concentration of the collateral measured by the share of transactions against that collateral in total: higher number indicates more concentration.
cptyandcollrating	Interaction term between counterparty rating and collateral rating

Table A.2: Tobit estimation of drivers of haircuts (excluding deals with CCPs)

	Reverse Repo					Repo				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Deal vars:										
notional	-0.016^{**}	0.002	0.002	-0.001	-0.001	0.003	0.002	0.001	0.001	0.001
maturity	0.119^{**}	0.116^{***}	0.106^{**}	0.070^{*}	0.084^{**}	0.029^{**}	0.031^{**}	0.034^{***}	0.035^{***}	0.037^{***}
Collateral vars:										
collrating		-0.013^{***}	-0.012^{***}	-0.011^{***}	-0.015^{***}		-0.001	-0.001	-0.001	0.000
collmaturity		0.003	0.002	0.004	0.008		0.003^{*}	0.003^{*}	0.003^{*}	0.003^{**}
securitisation		0.022	0.031^{*}	0.021	0.018	0.003	0.004	0.004	0.006	
var		0.006^{*}	0.005^{*}	0.005^{**}	0.005^{*}		0.013^{***}	0.012^{***}	0.012^{***}	0.012^{***}
asset in safe portf		-0.007	-0.009	-0.007	-0.009		0.001	0.000	0.001	0.001
Cpty type:										
brokerdealers			-0.027	-0.006	0.001			-0.011	-0.012	-0.011
hedgefund			0.098^{***}	0.067^{**}	0.057^{*}			-0.000	0.003	0.007
otherassetmanagers			0.031	0.018	0.017			0.022	0.026^{*}	0.024
insurance&pension			0.009	-0.019	-0.004			0.034^{**}	0.034^{**}	0.030^{**}
centralbank&government			-0.033	-0.016	0.001			0.054^{***}	0.057^{***}	0.051^{**}
other			0.078	0.049	0.038			0.005	0.002	-0.002
Cpty vars:										
cptysize				-0.203^{**}	-0.225^{***}				0.049^{*}	0.039
cptyroa				-0.018^{**}	-0.015^{**}				-0.006^{*}	-0.005
cptyrating				0.001	-0.015^{*}				-0.000	0.003
cptyleverage				0.107^{***}	0.100^{***}				0.007	-0.000
cptycds				0.020^{*}	0.012				-0.000	-0.002
cptycashratio				0.008	0.014				0.001	0.001
nocptydata				-0.124	-0.274				0.104	0.075
Misc:										
cptycon					0.013					0.009^{*}
collcon					0.012^{**}					0.007^{***}
cptyandcollrating					0.001^{***}					-0.000^{*}
N	3907	3907	3907	3907	3907	2915	2915	2915	2915	2915
R_p^2	2.379	2.628	2.689	2.734	2.790	-0.460	-0.476	-0.486	-0.489	-0.495

$^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Tobit regressions for reverse repo, columns (1)-(5), and repo, columns (6)-(10), excluding deals with CCPs. The dependent variable is haircut and explanatory variables are listed in the first column. All quantitative variables (notional, maturity, collmaturity, VaR, cptysize, cptyroa, cptyleverage, cptycds, cptycashratio, cptycon, collcon) are standardized. All regressions include bank, relationship, and currency fixed effects. Standard errors are clustered at the counterparty level.

Table A.3: The drivers of haircuts (excluding deals with CCPs) with time (month) fixed effects

	Reverse Repo					Repo				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Deal vars:										
notional	-0.012**	-0.000	-0.000	-0.002	-0.001	0.002	0.001	0.001	0.001	0.001
maturity	0.073*	0.072**	0.064*	0.031	0.048	0.060**	0.061**	0.061**	0.060**	0.060**
Collateral vars:										
collrating		-0.009***	-0.008***	-0.007***	-0.012***		-0.001	-0.001	-0.001	0.000
collmaturity		0.000	0.000	0.000	0.004		0.002*	0.002*	0.002*	0.002**
securitisation		0.018	0.029*	0.023	0.019		0.002	0.003	0.003	0.003
var		0.007**	0.006**	0.007***	0.006***		0.012***	0.012***	0.012***	0.011***
asset in safe portf		-0.003	-0.005	-0.004	-0.006*		0.001	0.000	0.001	0.002
Cpty type:										
brokerdealers			-0.017	-0.004	0.002			0.001	0.000	0.001
hedgefund			0.108***	0.079***	0.065**			-0.011	-0.004	-0.001
otherassetmanagers			0.032	0.023	0.019			0.012	0.016	0.014
insurance&pension			0.004	-0.024	-0.007			-0.006	-0.002	-0.006
centralbank&government			-0.007	-0.006	0.008			0.046**	0.052***	0.048**
other			0.080	0.053	0.041			-0.001	-0.000	-0.003
Cpty vars:										
cptysize				-0.136**	-0.153**				0.044*	0.033
cptyroa				-0.015**	-0.013**				-0.004	-0.002
cptyrating				-0.005	-0.020***				0.001	0.003
cptyleverage				0.079***	0.074***				0.005	-0.002
cptycds				-0.009	-0.013				-0.004	-0.005
cptycashratio				0.008	0.013*				-0.000	-0.000
nocptydata				-0.193	-0.297**				0.101	0.071
Misc:										
cptycon					0.010					0.011*
collcon					0.007*					0.004*
cptyandcollrating					0.001***					-0.000
N	3907	3907	3907	3907	3907	2915	2915	2915	2915	2915
R^2_{adj}	0.545	0.614	0.640	0.651	0.676	0.530	0.543	0.548	0.549	0.553

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
OLS regressions for reverse repo, columns (1)-(5), and repo, columns (6)-(10), excluding deals with CCPs. The dependent variable is haircut and explanatory variables are listed in the first column. All quantitative variables (notional, maturity, collmaturity, VaR, cptysize, cptyroa, cptyleverage, cptycds, cptycashratio, cptycon, collcon) are standardized. All regressions include bank, relationship, currency, and time (month) fixed effects. Standard errors are clustered at the counterparty level.

8 Online Appendix

Table O.1: The breakdown of value of contracts (in bn GBP) by maturity, currency, counterparty type, and collateral type. Sample of six banks excluding CCPs.

	REVR		REPO		
	Value	Percent	Value	Percent	Net
A. Maturity					
Overnight	23.4	23.7%	-33.0	24.4%	-9.6
1 day-3m	51.6	52.4%	-58.6	43.3%	-7.0
3m-1y	21.8	22.1%	-27.5	20.3%	-5.7
1y-5y	1.8	1.8%	-14.5	10.7%	-12.7
5y+	0.0	0.0%	-1.7	1.2%	-1.6
Total	98.6	100.0%	-135.3	100.0%	-36.7
B. Currency					
GBP	26.9	27.3%	-41.0	30.3%	-14.2
EUR	31.4	31.9%	-65.4	48.3%	-33.9
USD	27.4	27.8%	-25.2	18.6%	2.2
JPY	6.0	6.1%	-1.6	1.2%	4.4
Other	6.9	7.0%	-2.1	1.6%	4.8
Total	98.6	100.0%	-135.3	100.0%	-36.7
C. Counterparty type					
Another reporting bank [a]	8.2	8.3%	-10.2	7.6%	-2.0
Other banks	29.3	29.7%	-43.6	32.2%	-14.3
Broker-dealer [b]	15.0	15.2%	-15.8	11.7%	-0.8
Hedge fund	15.1	15.3%	-15.5	11.5%	-0.4
Other asset managers [c]	11.5	11.7%	-8.3	6.2%	3.2
Insurance and pension	9.5	9.7%	-8.5	6.3%	1.0
Central bank and government	5.5	5.6%	-28.6	21.1%	-23.0
Other [d]	4.4	4.5%	-2.8	2.1%	1.6
Other	0.0	0.0%	-1.9	1.4%	-1.9
Total	98.6	100.0%	-135.3	100.0%	-36.7
D. Collateral type					
US govt	10.2	15.3%	-5.4	6.7%	4.8
UK govt	14.5	21.7%	-17.6	21.9%	-3.1
Germany govt	5.4	8.0%	-12.9	16.0%	-7.5
France govt	4.9	7.3%	-4.7	5.9%	0.1
GIIPS	3.9	5.8%	-3.9	4.8%	0.0
Other sovereign	18.9	28.4%	-10.8	13.4%	8.2
Corporate debt	7.0	10.5%	-11.7	14.5%	-4.7
Securitization	1.9	2.9%	-13.5	16.8%	-11.6
Other	0.0	0.1%	0.0	0.0%	0.0
Total	66.7	100.0%	-80.4	100.0%	-13.8

The table presents the breakdown of the deals by maturity, currency, counterparty type, and collateral type (Panels A, B, C, and D respectively) for the sample of six banks excluding CCPs. For each category, it shows the value of the trades in billions GBP and the percentage of total trades for the reverse repos and repos respectively. The total values in Panels A, B, C and D are based on the data from the six reporting banks that report haircut and collateral information. Discrepancies in row Total between the Panels are due to missing information.

[a] The reporting banks report on a UK-consolidated basis, but counterparties are reported on a global basis. Therefore there may be discrepancies between the reverse repos and repos with the reporting banks.

[b] Broker-dealers are mostly securities firms that are subsidiaries of large banks. [c] Non-leveraged non-MMF mutual funds—asset managers that are not hedge fund or MMF. [d] Includes corporations, schools, hospitals and other non-profit organizations. [e] Greece, Italy, Ireland, Portugal, and Spain government bonds.

Table O.2: The breakdown of reverse repos

	Counterparty type								
	1	2	3	4	5	6	7	8	Total
A. Maturity									
Overnight	1.4	18.8	8.0	4.0	2.0	2.1	0.0	2.2	38.4
1 day-3m	0.81	17.5	9.3	10.1	5.6	5.5	2.6	2.2	53.9
3m-1y	0.3	1.7	0.3	0.3	2.5	1.6	0.5	0.5	7.6
1-5y	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
5y+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.5	38.2	17.7	14.4	10.1	9.2	3.1	4.9	100.0
B. Currency									
GBP	1.1	2.8	1.5	2.6	6.3	5.8	0.1	2.6	22.8
EUR	0.6	16.1	2.9	6.3	1.4	3.0	1.3	1.2	32.6
USD	0.7	15.6	11.1	4.0	2.2	0.2	0.7	0.9	35.6
JPY	0.0	1.5	0.9	1.3	0.3	0.0	0.0	0.2	4.0
Other	0.1	2.3	1.3	0.2	0.0	0.1	1.0	0.1	5.0
Total	2.5	38.2	17.7	14.4	10.1	9.2	3.1	4.9	100.0
C. Collateral type									
US govt	0.2	3.1	6.2	0.9	1.4	0.0	0.8	0.0	13.0
UK govt	0.1	0.6	0.9	0.3	7.4	4.9	0.2	2.4	16.8
Germany govt	0.3	1.2	0.4	0.6	0.6	0.6	1.1	0.1	4.9
France govt	0.0	1.7	0.2	0.4	0.3	1.1	0.1	0.2	4.0
GIIPS	0.0	0.2	0.0	3.6	0.1	0.2	0.4	0.0	4.6
Other sovereign	0.6	14.2	3.9	1.5	1.1	0.6	1.7	0.9	24.4
Corporate debt	1.0	10.9	3.3	4.8	1.8	1.9	0.1	2.6	26.4
Securitization	0.1	1.7	1.4	1.4	0.2	0.4	0.1	0.5	5.5
Other	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2
Total	2.3	33.7	16.5	13.6	12.9	9.6	4.5	6.8	100.0

This table exhibits a finer breakdown of the reverse repo contracts. The numbers are in percentage points and indicate the percentage of notional value in each category. The data is double sorted by counterparty type (columns) and maturity, currency and collateral type in Panels A, B, and C respectively. The table is based on the data from the the six banks that report haircut and collateral information. Columns 1–8 refer to the following counterparty types:
1. Another reporting bank
2. Other banks
3. Broker-dealer
4. Hedge fund
5. Other asset managers
6. Insurance and pension
7. Central bank & govt, and 8. Other

Table O.3: The breakdown of repos

	Counterparty type								
	1	2	3	4	5	6	7	8	Total
A. Maturity									
Overnight	3.5	25.6	10.7	4.8	5.8	1.0	1.7	0.4	53.2
1 day-3m	0.8	10.3	5.8	7.3	2.7	3.9	4.4	0.8	36.3
3m-1y	0.2	2.4	0.8	0.5	0.2	0.5	2.1	0.0	6.7
1-5y	0.3	1.7	1.5	0.0	0.0	0.3	0.0	0.0	3.8
5y+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	4.8	40.0	18.8	12.6	8.7	5.7	8.2	1.2	100.0
B. Currency									
GBP	0.6	1.9	2.2	2.3	2.3	2.8	2.2	0.4	15.1
EUR	1.4	20.9	7.3	6.8	4.5	0.9	4.9	0.5	46.9
USD	2.0	15.5	8.3	3.0	1.8	2.0	0.9	0.3	33.6
JPY	0.8	0.2	0.0	0.2	0.0	0.0	0.0	0.0	1.4
Other	0.0	1.5	1.0	0.2	0.1	0.0	0.1	0.0	2.9
Total	4.8	40.0	18.8	12.6	8.7	5.7	8.2	1.2	100.0
C. Collateral type									
US govt	0.5	1.9	0.6	0.1	0.2	0.0	0.4	0.0	3.7
UK govt	0.3	0.7	0.2	0.7	2.0	1.0	1.9	0.4	7.9
Germany govt	0.4	4.1	0.6	1.9	0.5	0.0	2.2	0.1	10.0
France govt	0.1	2.0	0.2	0.9	0.6	0.0	0.7	0.0	4.4
GIIPS	0.0	1.0	0.5	2.4	0.3	0.0	0.8	0.0	5.0
Other sovereign	2.2	8.3	4.1	2.5	0.8	0.3	2.1	0.3	20.5
Corporate debt	1.3	15.6	7.5	2.9	5.2	3.8	1.0	0.1	37.1
Securitization	0.6	6.5	2.9	0.2	1.1	0.2	0.1	0.0	11.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	5.3	40.0	16.6	11.7	10.8	5.5	9.2	0.9	100.0

This table exhibits a finer breakdown of the repo contracts. The numbers are in percentage points and indicate the percentage of notional value in each category. The data is double sorted by counterparty type (columns) and maturity, currency and collateral type in Panels A, B, and C respectively. The table is based on the data from the the six banks that report haircut and collateral information. Columns 1–8 refer to the following counterparty types:
1. Another reporting bank
2. Other banks
3. Broker-dealer
4. Hedge fund
5. Other asset managers
6. Insurance and pension
7. Central bank & govt, and 8. Other