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The repo market under Basel III

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Abstract

This paper assesses the impact of banking regulation (Basel III) on financial market dynamics using the repo market as an important case study. To this end, we use unique proprietary data sets from the Bank of England to examine the individual and joint impact of leverage, capital and liquidity coverage ratios on participants' trading in all collateral segments of the UK repo market. We find non-uniform effects across ratios and participants and non-linear effects across time. For instance, we find that the leverage ratio induces participants to charge lower (higher) interest margins on repo (reverse repo) trades that are non-nettable compared to the nettable ones. Second, we document a change in market microstructure under the new regulatory regime. Specifically, we evidence a substitution effect of banks' long-term repo borrowing backed by gilts from dealers to investment funds which can be fragile during times of stress. Likewise, we find an increasing prominence of central counterparties. Third, we find evidence that participants who are jointly constrained by multiple ratios and closer to the regulatory thresholds during times of stress reduce their activity to a greater extent than those that are constrained by a single ratio or not constrained, with implications for market liquidity.

Key words: Banking regulation, repo market, market microstructure, liquidity, monetary policy transmission.

JEL classification: G11, G21, G28, E44, E52.

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1 Introduction

The introduction of Basel III as a response to the global financial crisis has transformed the financial system. The imposition of stricter capital and liquidity requirements on banks has increased their resilience and ability to provide credit to the real economy even during times of stress, as evidenced in the ongoing Covid-19 crisis (BCBS, 2021; OECD, 2021). Moreover, the macroeconomic benefits, in particular on output growth are significant. A new study shows that the benefits of the finalisation and full implementation of Basel III is up to three times as large, measured in growth-at-risk terms, compared to the costs generated by a somewhat lower growth at the early stages of the regulatory implementation (Budnik et al., 2021).

Nonetheless, it has been argued that Basel III has also impaired the smooth functioning of certain markets. For example, the repurchase agreements (repo) market, which facilitates the flow of cash and securities in the financial system and is important for the efficient transmission of monetary policy, has experienced a drop in liquidity (CGFS, 2017). Previous research has mainly attributed this to the leverage ratio (LR) (Allahrakha et al., 2018; Duffie, 2018; Kotidis and van Horen, 2018), although one study has also looked at the effects of liquidity coverage ratio (LCR) on the repo market (Macchiavelli and Pettit, 2020). However, there is scarce evidence on how the different elements of Basel III interact to affect the repo market and its structure. Since the regulatory ratios target different aspects of banks' balance sheet risks, they could affect both the demand and supply of cash in the repo market across different collateral types. Previous literature has examined the interaction of capital, liquidity and borrower-based macroprudential tools in improving welfare (Aguilar et al., 2020; Eisenbach et al., 2014; Hinterschweiger et al., 2021; Millard et al., 2021; Vo, 2021), yet this analysis is lacking in a market context to understand how regulation can influence the dynamics and ultimately the structure of the market itself. Moreover, there is still a gap in understanding the unintended or undesired behavioural incentives that regulation may create. This is crucial to examine in light of the market turmoils of September 2019 and March 2020 which showcased that a dysfunctional repo market can prove destabilising for the financial system and impair the smooth transmission of monetary policy (BoE, 2020, 2021a).

In this paper, we investigate the effects of three key Basel III regulatory ratios, the leverage ratio (LR), the capital ratio (CR) and the liquidity coverage ratio (LCR), on all segments of the UK repo market. We cover trades backed by government bonds as well as lower-quality collateral (e.g. corporate bonds and equities) utilising proprietary datasets from the Bank of England containing UK repo transactions and holdings. Our aim is two-fold: to assess how each ratio affects prices and volumes by effectively influencing banks' trading behaviour across different collateral segments (first-order effects[1]), and to investigate how the combined

[1] Sometimes interpreted as intended effects.

ratios may affect the structure of the repo market and participants' behaviour during stress (higher-order effects[2]). Yet, note that the paper does *not* aspire to provide a complete evaluation of costs and benefits of the Basel III regulation on the overall resilience of the financial system.

Beginning with first-order effects and *volumes*, we find that a stricter (i.e. higher) LR reduces repo borrowing backed by gilts. This is consistent with findings from previous papers, since the LR disproportionately penalises low-risk and low-margin activities such as repo intermediation backed by government bonds because it requires banks to hold capital against their assets irrespective of their riskiness. Hence, an increase of the distance of the ratio from the regulatory requirement leads to a reduction of this activity in order to decrease leverage. This increase can reflect enhanced market discipline following the introduction of Basel III, which also included greater disclosure requirements (Pillar 3). Second, we find that a stricter Tier 1 CR reduces repo borrowing backed by lower-quality collateral. This is because the CR takes into account the collateral's riskiness and assigns risk weights accordingly, which leads to a reduction of activity in this segment of the repo market as the ratio increases. Third, we find that a stricter LCR reduces reverse repo lending backed by lower-quality collateral of maturities greater than 30 days. This is because the LCR penalises the exchange of cash for lower-quality assets for long maturities to discourage banks from encumbering their liquidity for long periods of time. In addition, the LCR also reduces repo borrowing backed by gilts of maturities greater than 30 days because it incentivises banks to finance their stock of high-quality liquid assets (HQLA) using their own resources rather than borrowing in the repo market. Furthermore, we find that the LCR reduces collateral swap downgrades which have a negative effect on the ratio and increases collateral swap upgrades which benefit it. In terms of *prices*, we find that a stricter LR induces banks to request lower rates on non-netted repo borrowing transactions compared to the corresponding netted ones, and higher rates on non-netted reverse repo lending transactions compared to the corresponding netted ones. This is because while netted trades are exempt from the LR penalty, the banks pass on the balance sheet cost of non-netted trades to their counterparties.

Turning to the higher-order effects and the evolution of the repo market's microstructure, we first find evidence for a substitution of long-term borrowing of banks from dealers to investment funds. However, investment funds, as a source of funding, can be fragile. During times of stress, such as the Covid-19 market turmoil, they reduce their long-term lending activity. In addition, we document the increasingly prominent role of central counterparties (CCPs) in the UK repo market as banks are incentivised to trade through them in order to net their trades and reduce the impact of their activity on the LR. Finally we find that under stress, banks that are either jointly constrained by the LR and LCR or closer to both regulatory thresholds reduce their gilt repo borrowing and reverse repo lending activity to a greater extent than banks that are

[2] Sometimes interpreted as unintended effects.

either constrained by one ratio or unconstrained. This effect is non-linear and showcases that banks can drastically reduce their aggregate activity as their buffers get depleted during stress in order to avoid stigma effects and negative market reaction.

Our paper contributes to several strands of literature. First, our findings contribute to the the empirical literature on the post-financial crisis evolution of the repo market in light of the new regulatory regime. Allahrakha et al. (2018) find that following the introduction of the LR in the US, banks reduced their repo borrowing backed by high-quality collateral. At the same time, they increased the use of repo backed by more volatile collateral, and non-bank dealers increased their presence in the market. Bicu-Lieb et al. (2020) find a reduction of liquidity in the interdealer gilt repo market in recent years but do not document a causal relationship with the introduction of the LR. Kotidis and van Horen (2018) look at the dealer-client gilt repo market and find that following a change of LR reporting standards in the UK, constrained UK dealers reduced repo liquidity towards small clients only. They also find that unaffected foreign dealers stepped in to substitute the reduced supply from constrained UK dealers. Ranaldo et al. (2021) analyse the joint effects of EMIR and Basel III regulations and find a reduction of repo rates through a combination of increased reverse repo supply from CCPs and reduced repo demand from banks. Noss and Patel (2019) find an increase in the cost of repo borrowing for end-users in the gilt repo market due to the reduced willingness of dealers to intermediate following the introduction of the LR. He et al. (2021) describe how the LR constrained dealers from accommodating large US Treasuries sales and repo borrowing from investors during the dash-for-cash in March 2020, which contributed to the illiquidity of the Treasuries market and increased repo rates while Hüser et al. (2021) find that banks preferred transacting in the cleared rather than bilateral segment of the gilt repo market. Macchiavelli and Pettit (2020) examine the effects of the LCR on the US repo market and find that after its implementation banks extended the maturity of repos backed by lower quality collateral, reduced their reliance on repos to finance their HQLA stock, and reduced collateral downgrade trades with clients. By looking at all Basel III regulatory ratios jointly and simultaneously across all segments of the UK repo market, we are able to go beyond existing studies and draw conclusions on the structural effects of prudential regulation on financial markets.

In parallel, a considerable literature has investigated the effects of prudential regulation on banks' credit intermediation capacity. In general, they find that the measures have the intended effects by dampening risks on banks' books and reduce bank balance sheet size and volatility. However, they also find some side effects. Those include reduced credit supply or intermediation capacity, lower desire to finance more innovative projects that have a higher risk-return profile or less collateral, stronger effects on the lower tail of the income or wealth distribution, or lower output growth (Aguilar et al., 2020; Bentzen et al., 2020; Carpantier et al., 2018; Cerutti et al., 2017; Frost and van Stralen, 2018; Gerba and Mencia, 2019; Hinterschweiger et al., 2021). In addition, several papers have examined the leakage effect of macroprudential policies as tighter bank capital requirements lead to a substitution of lending from banks to shadow banks (Aikman et al., 2018; Begenau and Landvoigt, 2021; Cizel et al., 2019; Fève et al., 2019; Gebauer and Mazelis, 2020). Yet, there is a shortage of papers that try to model higher-order effects of regulation on financial market, in particular focusing on non-credit activity. This paper aims to fill this gap.

Finally, our paper contributes to the literature that examines the determinants of repo market liquidity and the role of central bank operations. Fleming et al. (2010) document the beneficial effects of the Federal Reserve's (Fed) Term Securities Lending Facility during the financial crisis in reducing repo spreads between Treasuries and lower-quality collateral. Martin et al. (2014) discuss the fragility of the tri-party repo market and its inability to provide liquidity during stress using a theoretical model. Corradin and Maddaloni (2020) and D'Amico et al. (2018) document the increased repo specialness due to collateral scarcity induced by the European Central Bank's (ECB) and the Fed's asset purchases respectively. Boissel et al. (2017), Copeland et al. (2014), Gorton and Metrick (2012), Krishnamurthy et al. (2014) and Mancini et al. (2016) discuss the financial stability implications of a dysfunctional and illiquid repo market. We contribute by exploring the (unintended) impact of post-crisis regulations on liquidity (prices) and volumes, in normal as well as stress periods. As far as we are aware, we are also the first study in this literature to focus solely on the UK.

Policy-wise, this study aims to provide valuable input for the evaluation of Basel III reforms. More than a decade after implementing these prudential measures, the Basel committee and the Financial Stability Board (FSB) are currently taking stock of how successful these have been in curbing the risks that led to the global financial crisis (GFC), and which aspects to adapt. This paper is a key bit in this puzzle, as it simultaneously pins down effectiveness alongside other (unexpected or undesired) effects of prudential regulation on financial markets. Many studies have focused on credit intermediation, especially bank-driven, so studies that focus on markets and market-based finance are in short supply but high policy demand, as documented in the recent Financial Stability Report of the Bank of England (BoE, 2021b). That same report highlighted that a rising share of UK financial intermediation has moved to the market-based segment. In particular, the report points to hedge funds playing a larger role in more traditional segments of bank-based finance. Our paper confirms that, and provides systematic evidence for hedge funds stepping in to substitute long-term reverse repo lending to banks from dealers, and more broadly for activity increasingly migrating to market-based finance. Yet, we also provide firm evidence of fragility of this source of financing, in particular during times of stress. In parallel, we notice an increase in CCP participation. While it should make the market more resilient, it may also lead to differential pricing of netted versus non-netted trades, contributing to fragmentation. Altogether, we see how non-banks substitute banks' activities in financial markets, yet the outcome is mixed. While institutions like hedge funds may make the system more fragile during times of stress, CCPs increase resilience while proliferating fragmentation. Finally, our paper is among the first to document microsturcture effects. It sheds light on the (endogenous) adjustment to regulation that repo market dealers and participants have undertaken to find new ways to intermediate or allocate funding. Policy-makers should continue to track these structural shifts in order to make a balanced assessment of the overall regulatory effects, including whether the regulatory perimeter should be expanded or calibrated.

The rest of the paper is structured as follows. In section 2 we provide an overview of the Basel III regulatory ratios and the repo market. In section 3 we discuss the potential effects of the ratios on the repo market and formulate our hypotheses. In section 4 we describe the data used in this study. In section 5 we present the results of our analysis, and finally in section 6 we conclude. Further technical details can be found in the appendix.

2 Basel III regulation and repo intermediation

Before we describe our analytical approach, it is useful to provide an overview of the key elements of the Basel III regulation relevant for the repo market, that will also motivate our subsequent hypotheses.

2.1 Basel III regulation

Basel III was introduced in the aftermath of the GFC to reform the banking system by setting international standards on minimum capital and liquidity requirements. Banks were required to hold additional capital both on a risk-weighted basis via the capital ratio, defined as available capital divided by risk-weighted assets, as well as on a non-weighted basis via the leverage ratio, defined as available Tier 1 capital divided by (unweighted) exposures. While the capital ratio takes into account the riskiness of the banks' assets, the leverage ratio treats all exposures equally irrespective of their riskiness. In this way, the leverage ratio acts as a backstop to the capital ratio because it does not depend on modelling assumptions regarding the assets' riskiness, and imposes a limit on banks' leverage. Capital requirements can be (i) minimum requirements or (ii) buffers. While the former must be met at all times, the latter can be used during times of stress to allow banks to withstand losses and continue lending to the real economy. One of these buffers, the countercyclical capital buffer (CCyB), is used to counteract the procyclical nature of the credit cycle by ensuring that banks accumulate capital during normal times and release it during times of stress. In the UK, the CCyB was introduced in 2016 and is being updated according to the prevailing economic conditions. It was increased from 1% to 2% in December 2019 (with a one-year implementation period), but was reduced to 0% during to the Covid-19 pandemic to facilitate credit extension to the real economy (BoE, 2020). Of course, the released capital can also facilitate increased intermediation in important markets such as repo. In our specifications later on, we test this conjecture in the context of the Covid-19 stress.

On liquidity requirements, Basel III introduced two ratios, the liquidity coverage ratio and the net stable funding ratio (NSFR). NSFR, defined as available amount of stable funding divided by required amount of stable funding, aims to make banks resilient over a longer-term horizon by incentivising them to fund their activities with stable sources of funding. LCR, defined as the total stock of high-quality liquid assets divided by net outflows over a stress period of 30 days, aims to make banks resilient to short-term funding shocks by requiring them to hold enough HQLA to withstand outflows for a stress period of 30 days. HQLA are classified according to their characteristics into level 1 (L1), which include the highest-quality assets such as central bank reserves, cash and top-rated government bonds, level 2A (L2A) which include other government bonds and highly-rated investment-grade corporate bonds, and level 2B (L2B) which include other investment-grade corporate bonds and certain equities. All non-HQLA eligible assets are classified as other assets for calculating the LCR. Each category is assigned a different run rate, which represents the fraction of the value that is assumed to be withdrawn during the 30-day stress period. L1 assets are assigned a 0% run rate, L2A assets are assigned a 15% run rate, L2B are assigned a 25% or 50% run rate, while other assets are assigned a 100% run rate. An international comparison of the Basel III implementation is provided in Appendix A.

2.2 Repo market overview

Next, we wish to describe the UK repo market, both in terms of the institutional set-up and the participants. A repo transaction involves selling a security and agreeing to buy it back at a later date for a pre-agreed price. The security acts as collateral in the case the seller cannot buy it back and offers counterparty risk protection to the buyer who can sell it in order to limit losses. The difference between the sell price and the repurchase price determines the interest rate paid by the seller to borrow cash and is known as the **repo rate**, or price of the contract. The buyer can demand collateral haircuts to further reduce the risk of losses in case of a counterparty default by overcollateralising the loan. The transaction is called **repo** from the cash borrower's perspective and **reverse repo** from the cash lender's perspective. When a pre-specified security is exchanged as collateral, the transaction is known as **special repo**. On the other hand, when any security satisfying certain criteria, such as specific credit rating, is accepted the transaction is known as **general repo**. In special repo trades, the rate is typically *lower* compared to general repo, or even negative as demand is driven by cash lenders who are willing to pay interest to obtain the security (e.g. for collateral management purposes). In general repo trades the rate is typically higher and positive as demand is driven by cash borrowers who seek funding.

The UK repo market is dominated by bank dealers that intermediate transactions mostly backed by UK government bonds, or **gilts** (Kotidis and van Horen, 2018). A wide range of other institutions also participate in the repo market including non-dealer banks, money market funds, central counterparties and corporates that invest cash through reverse repos. Hedge funds, pension funds, asset managers and insurance companies, on the other hand, borrow cash through repos to finance their investments (Bicu-Lieb et al., 2020; Hüser et al., 2021). The market includes transactions that occur between bank dealers (i.e. interdealer segment), which are mostly cleared through CCPs, and transactions that occur between dealers and clients that are mostly traded *bilaterally* (Kotidis and van Horen, 2018).

Apart from repos, we also examine a closely related market, that of **collateral swaps** given their sizeable volumes. In a collateral swap, the two counterparties exchange collateral rather than cash. Hence, the swap can be a collateral upgrade if the bank exchanges low-quality collateral for a higher-quality one, or a collateral downgrade if the reverse occurs. Banks enter into such transactions either for collateral management purposes, e.g. to obtain high-quality collateral for derivatives margining obligations, or to satisfy client demand for such securities (Macchiavelli and Pettit, 2020). Collateral swaps are important because they are also used by banks to manage their liquidity positions specifically in relation to their LCR, as will be discussed next.

3 Hypothesis development

In this section we outline the theoretical underpinnings and our analytical strategy for identifying the dynamic effects of Basel III regulation. We proceed to use those to develop our hypotheses. In particular, we will examine the *first-order effects*, which include the direct impact of any individual regulatory ratio on volumes and prices across different segments of the repo market; and the *higher-order effects* which instead aim to identify the broader, general equilibrium type of effects on market microstructure.

3.1 First-order effects

3.1.1 Volumes

The Basel III regulatory ratios affect volumes in different segments of the repo market. Repo borrowing backed by high-quality collateral such as government bonds increases the size of the balance sheet, binding more capital. Hence, the LR, being a non-weighted risk measure, can have a disproportionate effect on these transactions. This is the most well-documented effect of Basel III on repo intermediation, with extensive research indicating that it leads to a reduction of government bond-backed repo intermediation (which is a high-volume low-margin activity) especially during times of stress like the Covid-19 market turmoil of March 2020 (Allahrakha et al., 2018; Duffie, 2018; He et al., 2021; Kotidis and van Horen, 2018; Ranaldo et al., 2021).

In addition, the LCR can have an indirect impact on repo borrowing backed by government bonds, even though it does not directly affect this activity since it treats L1 securities equivalent to cash by assigning a 0% run rate on them. Specifically, the indirect impact stems from the fact that pledging a security as collateral in a repo borrowing transaction encumbers it as it will be owned by the counterparty if the borrower defaults. However, the LCR only considers unencumbered assets counting towards the pool of HQLA, which incentivises banks to finance their HQLA stock using their own resources rather than borrowing in the repo market, leading to a reduction of such activity (Macchiavelli and Pettit, 2020).

We thus hypothesize that a stricter LR will reduce participants' repo borrowing volumes backed by level 1 collateral such as gilts due to its equal treatment of balance sheet expanding activities irrespective of riskiness, while a stricter LCR will reduce them as participants increase their HQLA stock.

H1: Banks/dealers reduce repo borrowing backed by level 1 collateral as they adjust to higher LR and LCR.

Turning to transactions backed by lower-quality collateral (i.e. L2A, L2B and other), the CR is likely to be the binding constraint as Basel III imposes a capital charge on both sides of the transaction, hence affecting both repo borrowing and reverse repo lending. Since the ratio takes into account the collateral's riskiness, it makes repo transactions backed by higher-quality assets more attractive than lower-quality ones as the former carry a smaller or zero risk weight, working in the opposite direction of the LR. In other words, the CR reduces banks' incentives to enter repo and reverse repo transactions backed by lower-quality collateral. We thus hypothesize that a stricter CR will reduce participants' repo borrowing and reverse repo lending volumes backed by lower-quality collateral due to the assignment of a positive risk weight on these transactions.

H2: Banks/dealers reduce repo borrowing and reverse repo lending backed by lower-quality collateral as they adjust to higher CR.

In addition, the LCR incentivises banks to increase the maturity of repo borrowing transactions backed by lower-quality collateral to more than 30 days in order to avoid relying excessively on short-term funding.[3] Conversely, the LCR incentivises banks to reduce the maturity of reverse repo lending against lower-quality collateral to less than or equal to 30 days in order to avoid encumbering their liquidity for long periods of

[3]For example, an overnight repo backed by a level 2B asset with a run rate of 25% implies that at maturity 25% of the repo value is assumed to be withdrawn, so 25% of the collateral is returned as unencumbered HQLA. Hence the denominator increases by 25% of repo value while the numerator increases by 25%*75%=18.75% because of the haircut of the asset. As a result LCR drops.

time. We thus hypothesize that a stricter LCR will reduce participants' reverse repo lending volumes backed by lower-quality collateral for maturities greater than 30 days due to the assignment of positive run-off rates on these transactions.

H3: Banks/dealers reduce reverse repo lending backed by lower-quality collateral for maturities greater than 30 days as they adjust to higher LCR.

Finally, the LCR can affect collateral swap trades. Specifically, the LCR incentivises collateral upgrade trades which increase the ratio and penalises collateral downgrade trades which decrease it, irrespective of maturity.[4] Banks use such transactions to actively manage their LCR. As reported recently by the ECB, some European banks window-dress their balance sheets by entering into collateral swaps that mature just after the 30 day threshold in order to improve their LCR.[5] We thus hypothesize that a stricter LCR will increase (reduce) participants' collateral upgrade (downgrade) trades volumes irrespective of maturity due to the beneficial (detrimental) effect on HQLA.

H4: Banks/dealers reduce (increase) collateral downgrade (upgrade) trades volumes as they adjust to higher LCR.

3.1.2 Prices

The LR capital charge can be mitigated if transactions are netted with the same counterparty (CGFS, 2017). Two opposing (repo and reverse repo) trades can be netted when they are transacted with the same counterparty on the same day, have the same settlement and maturity dates and same transaction amount. Netting is greatly facilitated by CCPs, as they intermediate all trades in centrally cleared markets. However, since CCP membership is expensive and usually reserved only for banks, CCPs in the UK are mostly prevalent in the interdealer market while the dealer-client market remains mostly bilateral. As such, the LR can lead to differential repo rates (prices) in the two segments, with clients receiving (incurring) lower (higher) rates due to the regulatory cost if the banks do not net trades with them (CGFS, 2017). We thus hypothesize that the LR will induce a lower (higher) repo rate for non-nettable repo (reverse repo) trades compared to nettable ones.

H5: Banks/dealers impose lower (higher) repo rates for repo (reverse repo) non-nettable trades compared to nettable ones as they adjust to higher LR.

[4]For example, a trade of a level 2A asset (15% run rate) for a level 1 asset (0% run rate) results in an increase of HQLA as the former only counts for 85% of value while the latter counts for 100%. Conversely, a collateral downgrade leads to a reduction of HQLA and LCR. Since there is no cash exchange, the denominator of LCR, net outflows, remains unchanged.

[5]See page 24 in `https://www.bankingsupervision.europa.eu/press/pr/date/2019/html/ssm.pr191007_annex~537c259b6d.en.pdf`.

3.2 Higher-order effects

3.2.1 Market microstructure

By penalising certain transactions and incentivising others, the Basel III regulatory ratios can alter the broader repo market microstructure over a longer period of time. As mentioned previously, the LCR penalises long-term (greater than 30 days) reverse repo lending backed by lower-quality collateral. This could over time lead to a substitution of such lending from banks to non-bank financial institutions which are not bound by the LCR (CGFS, 2017; Cunliffe, 2020). The financial stability ramifications of this substitution remain unclear, and would depend on whether non-banks remain resilient during times of stress and continue providing funding.

In addition, as discussed above, the LR charge can be mitigated via trade netting. Since CCPs intermediate all trades in centrally cleared markets, they facilitate greater netting efficiency which lowers the regulatory cost of repo transactions. As a result, the LR can incentivise the migration of trading activity through CCPs. While currently this is mostly reserved to the interdealer segment of the UK repo market, ongoing international policy discussions debate whether it is prudent to expand CCP membership to non-bank financial institutions to broaden the scope for trade netting (BoE, 2021a; CGFS, 2017).

We thus hypothesize that dealers will reduce long-term lending to banks while investment funds will increase it, and that participants will increase trading through CCPs.

H6a: Banks substitute long-term repo borrowing from dealers to investment funds due to the LCR.

H6b: Banks increase trades through CCPs due to the LR.

3.2.2 Joint ratio constraints

The regulatory ratios are more likely to jointly constrain activity during times of stress due to extreme market volatility. Banks that face (or are in the close region of hitting) joint constraints may reduce overall volumes, both on repos and reverse repos, to a greater extent than banks that are constrained by one single ratio, or none. This can have a negative effect on market liquidity, which under certain circumstances can inhibit the effective transmission of monetary policy and induce central banks to directly intervene in this market, as observed in recent stress episodes.

Therefore we hypothesize that participants that are jointly constrained during times of stress will reduce repo borrowing and reverse repo lending more compared to those that are individually constrained or not constrained at all.

H7: Banks/dealers that are jointly constrained by multiple ratios reduce repo borrowing and reverse repo lending more compared to those that are individually constrained or not constrained during times of stress.

Similarly, we hypothesize that the price differential between netted and non-netted trades will increase even further during times of stress as the LR becomes more constraining due to market stress and the banks are forced to exit transactions that have a negative impact on the ratio.

H8: Banks/dealers increase the price differential between netted and non-netted trades during times of stress compared to normal times due to a more constraining LR.

4 Data overview

In order to test our hypotheses we make use of three proprietary datasets. We provide a brief overview of each in this section and a more detailed discussion in Appendix B. For repos backed by gilts we utilise the Sterling Money Market Data (SMMD),[6] a proprietary database of the Bank of England that records almost all daily repo and reverse repo transactions backed by gilts with maturities from overnight to one year. For each transaction, data on volume, pricing, collateral, segment (general collateral (GC) or special collateral (SC)) as well as the identifier of both counterparties is provided. The database covers both the interdealer and the dealer-client repo market segments, and includes transactions starting from 1st February 2016.

While the participants are obligated to report their gilt-backed repo transactions to SMMD, they only voluntarily report transactions backed by other sterling-denominated fixed income securities such as corporate bonds, so the coverage is imperfect. Hence, for our analysis of repos backed by lower-quality collateral we use the the Bank of England's internal database containing the PRA110 liquidity return. Reporting entities provide aggregate repo and reverse repo holdings at a weekly frequency, broken down by the LCR classification of collateral (i.e. levels 1, 2A, 2B and other, the last one containing all non-HQLA eligible securities which attract a 100% run rate as explained in the previous section) as well as maturity bucket (i.e. less or more than 30 days).[7] The database also contains the banks' collateral swap holdings which we use for our analysis. PRA110 starts from July 2019 and does not feature the granularity of SMMD, so it is not possible to identify counterparties. While this somewhat restricts our analysis on the segment of the repo market backed by lower-quality collateral, it provides us with sufficient data to estimate the main effects of Basel III on it.

Finally, we extract the banks' reported Basel III ratios including the LR, the LCR and the Tier 1 CR from the Bank of England's internal database containing the Capital Requirements Regulation (CRR) returns. All ratios are reported at a quarterly frequency with the exception of LCR, which is reported monthly. In

[6] https://www.bankofengland.co.uk/-/media/boe/files/statistics/data-collection/smm/instructions_smm.pdf?la=en&hash=D8B9947B4F07CD47431AD2352AC59F1AA6E19539

[7] https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/regulatory-reporting/banking/pra110-instructions-jan-2020.pdf

case of missing values, we complement the dataset with data from the banks' publicly available quarterly reports.

5 Results

5.1 First-order effects

Following the sequence of our hypotheses, we begin the analysis by investigating the first-order effects. To this end, we focus on different segments of the repo market based on collateral type in order to isolate the effects of each ratio based on our hypotheses formulation. We run panel regressions at the institution level, which allow us to quantify the impact of the regulatory ratios while controlling for a host of other factors. The main specification is:

$$Y_{i,t} = \alpha + LCR_{i,t-1} * ST_{i,t} + LCR_{i,t-1} * LT_{i,t} + CR_{i,t-1} + LR_{i,t-1} + \mu_i + \mu_t + \epsilon_{i,t} \tag{1}$$

where $Y_{i,t}$ is the dependent variable of interest, either the logarithm of total volume of institution i at quarter t, or the excess rate (repo rate - Bank rate). The independent variables are $LCR_{i,t-1}$, the lagged liquidity coverage ratio, $CR_{i,t-1}$, the lagged Tier 1 capital ratio,[8] and $LR_{i,t-1}$, the lagged leverage ratio.[9] We further split $LCR_{i,t-1}$ into short-term (≤30 days) and long-term (>30 days) trades using the corresponding dummy variables $ST_{i,t}$ and $LT_{i,t}$ as its effects depend on the maturity of the trades. We use quarterly frequency in the main specification to match the reporting frequency of the regulatory ratios. We include bank and time fixed effects which control for, respectively, time-invariant unobservables that affect each bank individually and time-varying unobservables that affect all banks equally.[10] We also experimented with bank-specific variables that capture their size (i.e. the logarithm of total assets) and riskiness (i.e. CDS spread), but they were insignificant and tended to inflate the standard errors, so we do not include them in the final specification. We also included bank yearly volume as a proxy for sophistication given that sophisticated investors/institutions typically transact more frequently and with higher volumes (Hau et al., 2017; Li and Schürhoff, 2019) which could also have an impact on the regulatory ratios, and the results are robust. The standard errors are double-clustered at the bank-and time levels. The regressions were estimated using OLS, although the results are virtually the same using MLE or GMM.[11]

[8]The results are the same if we use the CET1 capital ratio instead of the T1 capital ratio.

[9]The results are robust if we use the distance of each ratio from the regulatory threshold instead of the ratios themselves.

[10]Time fixed effects control for market-wide factors such as unconventional monetary policy, order imbalance, repo rate volatility and total volume traded. We calculated these variables and included them in the regressions after removing the fixed effects and some of them were significant, although our main results were unaffected. Since these variables are collinear with the time fixed effects, which also control for other potential unobservable factors, we removed them in favour of the fixed effects.

[11]Unreported results can be provided upon request.

Table 1: Repo borrowing volumes backed by gilts and regulatory ratios. This table reports estimates from OLS regressions of quarterly gilt general collateral and special collateral repo transaction volumes on the regulatory ratios using the SMMD dataset. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020.

Dependent Variable:	Log(Volume) (t)	
	(1) (SMMD GC)	(2) (SMMD SC)
LCR (%) $(t-1)$ * ST	0.016***	0.017***
	(3.676)	(5.504)
LCR (%) $(t-1)$ * LT	−0.009*	−0.010**
	(−2.022)	(−2.754)
CR (%) $(t-1)$	0.087	−0.007
	(1.411)	(−0.152)
LR (%) $(t-1)$	−0.304***	−0.134*
	(−3.430)	(−1.986)
Intercept	21.781***	23.246***
	(20.381)	(20.712)
Quarter fixed effects	Yes	Yes
Bank fixed effects	Yes	Yes
Observations	532	870
R^2	0.765	0.796

5.1.1 Volumes

We begin by testing *H1*, on the effects of the LR and LCR on repo borrowing backed by gilts. In Table 1 we report the results of our specification using quarterly volumes of general and special collateral repo borrowing volumes from SMMD, separately in columns (1) and (2). As can be seen, the coefficient of LR is negative and significant for GC trades and equal to −0.304, meaning that for a 1% increase of the LR, subsequent repo borrowing backed by gilts is reduced by approximately 30.4%. In other words, as banks adjust to higher ratio levels and increase the distance from the regulatory threshold, they decrease their repo borrowing activity. For SC trades the coefficient is marginally statistically significant but economically still significant implying a reduction of 13.4%. Qualitatively, the results are similar to those of an ECB study on the euro area repo market (Grill et al., 2017) and validate our hypothesis and previous findings in the literature that a stricter LR can reduce repo borrowing activity backed by high-quality collateral.

In addition, we observe that LCR has a positive coefficient for short-term trades but a negative one for long-term ones. Hence, while banks reduce their long-term repo borrowing backed by gilts as they increase their HQLA buffers as hypothesized, this is not the case for short-term trades. This could indicate that banks relied mostly on more stable long-term trades to increase their HQLA holdings, which is negated by the LCR regulation. This expands on the findings of Macchiavelli and Pettit (2020) who documented a reduction of US Treasuries being repoed out due to LCR but did not differentiate by maturity.

Next, we examine *H2* on the effects of the CR on repo borrowing backed by lower-quality collateral. For this analysis we rely on the PRA110 dataset. However, in order to ensure that the PRA110 results

Table 2: Repo borrowing volumes backed by lower-quality collateral and regulatory ratios. This table reports estimates from OLS regressions of quarterly gilt general collateral and special collateral repo transaction volumes in columns (1)-(2), and quarterly repo holdings volumes in columns (3)-(6) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from January 2020 to November 2020 for columns (1)-(3) and July 2019 to November 2020 for columns (4)-(6).

Dependent Variable:	Log(Volume) (t)					
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A)	(5) (PRA110 L2B)	(6) (PRA110 Other)
LCR (%) ($t-1$) * ST	0.002	0.009	0.003	0.009**	0.005	0.000
	(0.394)	(2.643)	(2.021)	(3.748)	(0.869)	(0.284)
LCR (%) ($t-1$) * LT	−0.023*	−0.020**	−0.006*	−0.003	0.005	0.003
	(−3.578)	(−4.739)	(−2.936)	(−0.930)	(0.659)	(1.801)
CR (%) ($t-1$)	0.227	0.179	−0.011	−0.188**	−0.482*	−0.152*
	(0.570)	(0.998)	(−0.159)	(−4.147)	(−2.445)	(−2.692)
LR (%) ($t-1$)	−0.515	0.195	−0.093	0.068	0.720	0.145
	(−0.913)	(0.582)	(−0.679)	(0.298)	(0.820)	(1.236)
Intercept	22.960**	20.035**	25.942***	24.961***	25.459***	25.899***
	(5.246)	(8.752)	(19.803)	(14.651)	(6.703)	(26.088)
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	94	166	115	161	220	178
R^2	0.847	0.825	0.872	0.916	0.525	0.861

are overall consistent with SMMD, we first compare the regression results for repo borrowing backed by L1 gilts from PRA110 with those from SMMD.[12] Since the sample for these holdings starts in January 2020 for PRA110, we use a subset of SMMD to match the start and end periods. The results are reported in columns (1)-(3) of Table 2. As can be seen, for the subset of SMMD from January to November 2020, the leverage ratio is no longer significant for GC or SC trades. However, the same holds for the PRA110 sample and the coefficients for all ratios are qualitatively and quantitatively similar between the two datasets. Hence, the PRA110 dataset can be used to infer the effects of the regulatory ratios on repo activity even with the lack of granularity offered by SMMD.

Examining columns (4)-(6) which contain repo borrowing holdings backed by L2A, L2B and other collateral respectively, it can be seen that the CR now becomes the constraining ratio while the LR becomes insignificant. Specifically, for a 1% increase of the T1 CR, repo borrowing backed by L2A, L2B and other collateral decreases by 18.8%, 48.2% and 15.2% respectively. This validates *H2* that a stricter CR reduces repo borrowing backed by lower-quality collateral.

Next, we assess the effects of the CR on reverse repo lending backed by lower-quality collateral. The results are presented in Table 3 where we consider reverse repo trades. As can be seen in columns (4)-(6) where we focus on volumes backed by lower-quality collateral, the CR has no effect. This indicates that the CR mainly affects the repo borrowing side, hence only partially validating *H2*.

[12]The results are qualitatively and quantitatively similar when we include all PRA110 L1 holdings, including gilts.

Moving to *H3*, we test the effects of the LCR on reverse repo lending. We expect that a stricter LCR will reduce reverse repo lending backed by lower-quality collateral of > 30 days. As can be seen in Table 3, LCR becomes the only constraining regulatory ratio for reverse repo volumes except for SC gilt reverse repo trades in column (2) where the LR remains significant. This could be due to matched-book trading performed by banks, whereby an impact of the ratio on repo borrowing can have a knock-on effect on reverse repo lending as well. Given that special collateral trades comprise the large majority of total transaction volumes, they are more likely to be affected by the LR on both repo and reverse repo sides. Focusing on long-term reverse repo volumes backed by lower-quality collateral in columns (4)-(6), we observe that LCR is negative and significant for reverse repo lending backed L2A and marginally significant for L2B as seen by the coefficients -0.010 and -0.005 respectively, while for other collateral it remains insignificant. The results provide evidence that a stricter LCR reduces reverse repo lending of more than 30 days backed by lower-quality collateral. The effects of LCR are in general smaller in magnitude compared to the LR and the CR because banks have LCR buffers far exceeding the regulatory threshold of 100%, with the average LCR being 156.94% (as discussed in the previous section). Hence, a 1% change of LCR would not have the same impact on market activity as a 1% change of LR or CR. However, LCR is more elastic and can change to a higher degree compared to the other ratios, so it is reasonable to interpret the results in LCR movements of 10%, implying that reverse repo lending backed by L2A and L2B collateral would reduce by 10% and 5% respectively.

When looking at long-term reverse repo lending backed by gilts in columns (1)-(3), while the PRA110 sample shows no significant impact of the LCR as would be expected given its equal treatment of cash and gilts, the SMMD sample interestingly shows a significant effect both on general and special collateral. This indicates that banks have a preference for cash over gilts as LCR closes in. While the reason behind this is not clear, it could be related to banks' preference for cash during times of stress when government bonds can become less liquid, as also reflected in regulatory liquidity stress tests.

Finally, we examine *H4* on the effects of LCR on collateral swaps. Specifically, we test the hypothesis that a stricter LCR will reduce collateral downgrades but increase collateral upgrades. The results using collateral swap outflows are presented in Table 4.[13] When examining outflows of L1 gilt collateral, which signify collateral downgrades, we observe negative LCR coefficients both on short-term and long-term trades of -0.047 and -0.040 respectively, which indicate that when LCR becomes stricter by 1% banks reduce short-term and long-term collateral downgrade trades by 4.7% and 4% respectively. When examining outflows of lower-quality collateral, L2B swaps have a negative LCR coefficient on short-term trades of -0.011. Since

[13]We focus on outflows because they represent a significantly larger volume compared to inflows as seen in Table B1, for which the results are mostly insignificant.

Table 3: Reverse repo lending volumes and regulatory ratios. This table reports estimates from OLS regressions of quarterly gilt general collateral and special collateral reverse repo transaction volumes in columns (1)-(2), and quarterly reverse repo holdings volumes in columns (3)-(6) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020 for columns (1)-(2), January 2020 to November 2020 for column (3) and July 2019 to November 2020 for columns (4)-(6).

Dependent Variable:	Log(Volume) (t)					
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A)	(5) (PRA110 L2B)	(6) (PRA110 Other)
LCR (%) ($t-1$) * ST	0.007*	0.013***	0.000	−0.007	−0.007*	−0.001
	(1.882)	(7.308)	(0.027)	(−1.961)	(−2.160)	(−0.654)
LCR (%) ($t-1$) * LT	−0.009**	−0.006***	−0.002	−0.010**	−0.005*	−0.002
	(−2.638)	(−3.077)	(−0.485)	(−4.118)	(−2.457)	(−1.522)
CR (%) ($t-1$)	−0.116	0.057	−0.121	−0.073	−0.089	−0.058
	(−0.953)	(0.883)	(−1.692)	(−0.454)	(−0.509)	(−0.756)
LR (%) ($t-1$)	−0.087	−0.177**	0.136	0.407	0.517	0.204
	(−0.595)	(−2.148)	(1.367)	(0.696)	(0.700)	(0.759)
Intercept	23.681***	22.732***	26.928***	24.261***	22.417***	24.630***
	(13.730)	(28.966)	(24.221)	(8.035)	(7.195)	(620.956)
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	457	895	116	173	230	180
R^2	0.565	0.787	0.841	0.841	0.650	0.904

L2B collateral could be swapped for higher (L1 or L2A) or lower-quality (other) collateral, it is not clear whether they represent upgrades or downgrades but the coefficient indicates that it is mostly the latter. When looking at swaps involving other collateral, which signify collateral upgrades, we observe a positive LCR coefficient of 0.007 for long-term trades, implying that when LCR becomes stricter by 1% banks increase collateral upgrade trades on a long-term basis by 0.7%. Hence, the results validate *H4* that LCR has an impact on collateral swap trades, consistent with previous findings in the literature (Macchiavelli and Pettit, 2020).

5.1.2 Prices

We now test *H5*, that the LR can induce differential prices (repo rates) between nettable and non-nettable trades. Since PRA110 does not provide information on transactions and repo rates, we focus on the gilt repo market using SMMD. We use excess rates, i.e. repo rate minus the Bank rate as the dependent variable. This is calculated on a quarterly frequency by averaging the rate in intraday transactions on a daily frequency, and then averaging the daily excess rates over a quarter for each institution.[14]

In order to tease out the differential impact of the LR on netted vs. non-netted trades, we use a dummy variable "Non-netted" which identifies non-netted trades and multiply it with the LR. In this way, the interaction captures the relative difference compared to the baseline LR which captures netted trades. As

[14]The results are even stronger when we use the repo rate instead of the excess rate as the dependent variable.

Table 4: Collateral swap volumes and regulatory ratios. This table reports estimates from OLS regressions of quarterly collateral swap outflows on the regulatory ratios using the PRA110 dataset. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from July 2019 to November 2020.

Dependent Variable:	Log(Volume) (t)			
	(1) (PRA110 L1)	(2) (PRA110 L2A)	(3) (PRA110 L2B)	(4) (PRA110 Other)
LCR (%) ($t-1$) * ST	−0.047*	−0.003	−0.011***	−0.005
	(−2.194)	(−0.557)	(−4.991)	(−2.006)
LCR (%) ($t-1$) * LT	−0.040*	−0.002	0.000	0.007**
	(−2.606)	(−0.520)	(0.042)	(4.402)
CR (%) ($t-1$)	0.578*	0.117**	0.234	−0.070
	(2.190)	(4.594)	(1.396)	(−0.953)
LR (%) ($t-1$)	−0.144	0.111	−0.748	0.166
	(−0.162)	(1.066)	(−1.963)	(1.184)
Intercept	17.521***	21.088***	23.661***	23.715***
	(217.367)	(18.238)	(8.565)	(21.351)
Quarter fixed effects	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	55	142	148	166
R^2	0.539	0.857	0.829	0.777

mentioned before, we assume that a transaction is netted if there exists an opposing transaction conducted on the same day with the same counterparty and has the same settlement and maturity dates and transaction amount.[15] We also split the trades into short-term and long-term ones because the impact could be stronger for the latter since they stay for longer periods of time on the balance sheet.

The results are presented in Table 5. We separately test for general and special collateral, on the repo and reverse repo trades. In column (1) we examine GC repo trades. As can be seen, while the coefficients for the leverage ratio on short and long-term trades are not significant, when multiplying with "Non-netted" there is a significant negative coefficient on short-term trades of −0.004. This means that, compared to short-term netted trades, the corresponding non-netted ones have an average excess rate that is 0.4 basis points (bps) lower for every 1% increase in the LR. Since these are repo trades where the banks are borrowing funds, they thus pass the cost on to lenders by requesting a lower rate. When looking at GC reverse repos in column (2), we instead observe a positive marginally statistically significant coefficient for long-term non-netted trades of 0.010, implying that when banks are lending funds for >30 days and the transaction is not netted, they request a 1 bp higher rate compared to a netted trade. When looking at special collateral trades, while there is no significant effect on repo trades in column (3), there is a significant positive effect on reverse repos in column (4) on both short and long-term trades. Short-term non-netted trades have a higher price compared to the corresponding netted ones by 0.6 bps while long-term non-netted trades have a higher price compared to the corresponding netted ones by 2.2 bps. In summary, the results validate *H5* and showcase that the LR

[15] The results are qualitatively and quantitatively similar if we do not match by maturity date.

Table 5: Gilt repo and reverse repo excess rates and regulatory ratios. This table reports estimates from OLS regressions of quarterly gilt general collateral and special collateral repo and reverse repo transaction excess rates on the regulatory ratios using the SMMD dataset. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020.

Dependent Variable:	Excess rate (Repo rate - Bank rate) (%) (t)			
	(1) (GC Repo)	(2) (GC Reverse repo)	(3) (SC Repo)	(4) (SC Reverse repo)
LCR (%) ($t-1$) * ST	−0.000	−0.000	0.000	−0.000
	(−0.459)	(−0.222)	(0.043)	(−0.424)
LCR (%) ($t-1$) * LT	0.000	0.000	0.000	0.000**
	(0.373)	(0.005)	(1.006)	(2.520)
CR (%) ($t-1$)	0.000	0.001	0.001	0.004
	(0.042)	(0.544)	(0.512)	(1.666)
LR (%) ($t-1$) * ST	0.001	−0.002	0.002	−0.007
	(0.253)	(−0.595)	(0.334)	(−1.255)
LR (%) ($t-1$) * LT	0.006	−0.006	0.006	0.004
	(1.274)	(−1.267)	(0.659)	(0.446)
LR (%) ($t-1$) * ST * Non-netted	−0.004***	−0.001	−0.000	0.006***
	(−2.930)	(−0.882)	(−0.343)	(6.241)
LR (%) ($t-1$) * LT * Non-netted	0.002	0.010*	−0.007	0.022***
	(0.673)	(1.996)	(−1.227)	(2.961)
Intercept	−0.017	0.001	−0.088***	−0.093*
	(−0.608)	(0.025)	(−3.114)	(−2.000)
Quarter fixed effects	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	757	680	1,363	1,390
R^2	0.519	0.380	0.188	0.542

can have an impact on prices, on top of the volume effects.

5.2 Higher-order effects

There are added challenges to empirically identify higher-order effects because all regulatory ratios had been announced by the time our sample starts. To overcome this, our approach consists of using variation across time, in particular since the ratios had not been fully phased in during the early part of the sample (2016-2018), in order to identify longer-term trends in the market. This will allow us to pin down endogenous adjustments in market structure across time against the baseline year. Moreover, since our sample includes two stress episodes generated by exogenous shocks, we are able to construct a quasi-natural experiment. It allows us to determine how dealers and participants adjust and behave under unexpected stress, when the buffers are quickly exhausted and there is a material risk of hitting the combined regulatory boundaries.

5.2.1 Market microstructure

In order to test hypotheses *H6a* and *H6b*, i.e. whether there is a substitution of banks' long-term borrowing from dealers to investment funds due to the LCR and whether banks increase trades through CCPs due to the LR, we focus on the gilt repo market because SMMD provides information on the identity of the transaction counterparties, in contrast to PRA110. While we would expect the substitution effect examined in *H6a* to mainly hold for repos backed by lower-quality collateral as explained in section 3, it could also be present in the gilt repo market if banks have a preference for cash over gilts as indicated by the first-order results on reverse repo lending.

Since we are interested in examining substitution effects, we separate banks from dealers[16] by only considering the trades reported by the former and transacted with dealers or other institutions. We run time-series regressions where the dependent variable is the logarithm of aggregate daily volume reported by all banks at a sectoral level. We then use dummy variables to classify each trade according to the year it was conducted, whether it is short-term or long-term, as well as the counterparty sector, i.e. if the counterparty is a dealer, a CCP, or market-based finance (MBF). For MBF, we consider three different classifications of increasing inclusion: (i) hedge funds, (ii) investment funds (including hedge funds and other funds), and (iii) investment funds, pension funds and insurers. With these dummy variables, we capture the evolution of the market over time in terms of average volumes across different maturities and counterparty sectors.[17] While we do not test the impact of the ratios directly in this analysis as we did previously, the specification allows us to examine whether there exist patterns that are consistent with regulatory predictions on the effects of Basel III on the repo market's structure (CGFS, 2017; Cunliffe, 2020).

For ease of exposition, we report the regression results graphically in Figure 1 while the numerical results are detailed in Table C1 in Appendix C. We use the year 2016 as the baseline, and all subsequent years are compared to 2016. In other words, the regression coefficients for years 2017-2020 capture relative differences compared to 2016. We use three different definitions of MBF: hedge funds (first panel second row in Figure 1 and columns (1) and (4) in Table C1 for repos and reverse repos respectively), investment funds including hedge funds (second panel second row in Figure 1 and columns (2) and (5) in Table C1 for repos and reverse repos respectively) and investment funds, pension funds and insurers (all MBF - third panel second row in Figure 1 and columns (3) and (6) in Table C1 for repos and reverse repos respectively).

Focusing on repo borrowing trades, we first examine trades where the counterparty is a dealer (first panel first row in Figure 1). Since the table columns only differ on the definition of MBF, the results for dealers and CCPs are virtually identical across columns (1)-(3) and (4)-(6) for repos and reverse repos respectively. On short-term trades, we observe that banks borrowed similar volumes from dealers in 2017 compared to 2016 as observed by the insignificant coefficient of 0.150 indicating no change, but in subsequent years they increased borrowing as indicated by the positive and significant coefficients of 0.971, 0.653 and 1.072 for years 2018,

[16]We classify dealers according to the gilt-edged market makers reported in the UK Debt Management Office, consistent with previous studies (Hüser et al., 2021; Kotidis and van Horen, 2018): `https://www.dmo.gov.uk/responsibilities/gilt-market/market-participants/`.

[17]We included as control variables daily returns of the VIX index, the FTSE 100 index and UK Libor but none of them were significant so we did not include them in the final specification.

2019 and 2020 respectively. To provide a perspective on the magnitude, the coefficients imply an increase of average daily repo borrowing volume between approximately £105 million (2019) and £220 million (2020) compared to 2016. However, when we examine long-term trades we observe that for all subsequent years the coefficients are negative and significant, implying that banks reduced long-term repo borrowing from dealers since 2016. The reduction ranges from £125 million on a daily average basis in 2019 to £201 million in 2018. While the reason behind this reduction is not clear, to the extent that it is linked to the Basel III ratios it could either be driven by banks which borrow less on a long-term basis to avoid a leverage ratio penalty, or by dealers who lend less as they prefer to hold on to cash rather than gilts (as discussed in the previous subsection). If it is due to the first reason, we would expect to observe this pattern across all counterparties. Hence, we now turn our focus on MBF.

On short-term trades, we observe that banks strongly increased short-term borrowing from hedge funds in all subsequent years, ranging from £1.1 billion in 2017 to £2.2 billion in 2019 on a daily basis as seen in the first panel second row of Figure 1 and in column (1) of Table C1. On long-term trades, banks kept daily repo borrowing constant in 2017 compared to the previous year, increased it in 2018 and 2019 as seen by the positive coefficients by about £20-30 million and reverted back to 2016 levels in 2020 as seen by the insignificant coefficient. This provides two insights. First, banks partially substituted long-term repo borrowing from dealers to investment funds as predicted in *H6a* and the results indicate that this was due to supply constraints from dealers rather than demand constraints from banks. Second, in 2020 long-term repo borrowing volumes scaled back to 2016 levels which could again be due to reduced demand by banks or reduced supply by hedge funds. If it is the latter, it could be an indication of MBF fragility to the extent that hedge funds step in during normal times to provide lending but scale back their activity during times of stress such as during the March 2020 market turmoil. We will investigate this insight later in this subsection.

When looking at the broader definitions of MBF in the second and third panels in the second row of Figure 1 and in columns (2)-(3) of Table C1, the effects are in general smaller in magnitude which highlights the prominent role of hedge funds in the repo market. Specifically, when looking at all investment funds in the second panel and in column (2), there was an increase of short-term borrowing as before, but long-term borrowing was less in 2017 compared to 2016, although it increased in 2018 and 2019 before dropping to 2016 levels again in 2020. When looking at all MBF, including investment funds, pension funds and insurers in the third panel and in column (3), there was a small increase of short-term borrowing from 2017 to 2019, but long-term borrowing largely remained at similar levels to 2016.

Finally, looking at repo trades with a CCP counterparty in the second panel first row of Figure 1 and in columns (1)-(3) of Table C1, we again observe a strong increase in short-term repo borrowing by banks in all subsequent years compared to 2016, ranging from £7.5 billion (2017) to £15 billion (2018). This validates

H6b and showcases the increasing importance of CCPs in the repo market and the preference of banks to transact through them due to the netting benefits they can provide in terms of the leverage ratio. However, this increase is only observed on a short-term basis as long-term trades remain at similar levels compared to 2016.

Next, we look at reverse repo lending of banks. In general, banks increased daily short-term lending to dealers from 2018 onward in the range of £84 million (2019) to £167 million (2018) as seen in the first panel first row of Figure 1 and in columns (4)-(6) of Table C1. On a long-term basis, lending remained mostly flat with the exception of 2019 where it increased by £101 million compared to 2016. On MBF, banks increased significantly average daily short-term lending to hedge funds in every subsequent year (first panel second row and column 4), ranging from £1 billion (2017) to £2.2 billion (2019), while long-term lending increased for all years except 2020, ranging from £16 million (2017) to £31 million (2018). Similar patterns are observed for short-term lending to investment funds (second panel second row and column 5) and all MBF (third panel second row and column 6), although smaller in magnitude. On long-term lending, banks continued lending to all MBF in 2020, which is consistent with the activity of pension funds which borrow large amounts to purchase gilts (Hüser et al., 2021). Finally, on CCP trades, banks increased short-term lending in all subsequent years, ranging from £5.7 billion (2017) to £7.9 billion (2019) (second panel first row and columns (4)-(6)). On long-term trades, they increased average daily lending in 2017 (£115 million) and again in 2020 (£109 million) compared to 2016. This is consistent with the findings of Hüser et al. (2021) who find that banks and dealers preferred to increase lending through CCPs rather than bilaterally during the Covid-19 market turmoil because of the netting benefits.

We now turn our attention to hedge funds. In Table C2 in Appendix C we repeat the analysis for repo borrowing and define as MBF hedge funds as in column (1) of Table C1. In order to understand whether the reduction of banks' long-term repo borrowing from hedge funds in 2020 compared to the previous year was concentrated in the market turmoil of March 2020, we first create a dummy variable called "Covid" that captures the period from end of February to end of April 2020 and interact it with the repo borrowing from hedge funds in 2020. As can be seen in column (1), the coefficient for long-term trades for the specific stress period was negative and marginally statistically significant -1.072, while the baseline coefficient for 2020 was insignificant (0.066), which indicates that the contraction in borrowing indeed occurred during the market turmoil.

Next, to infer whether this was due to a *demand* or *supply* shock, we run the regression at the individual bank level and split the banks into two groups according to their leverage ratio at the end of February 2020. Specifically, we split the banks into two quantiles of the leverage ratio to separate those that are closer to the minimum regulatory threshold (we label them as bucket 1, or "B1") and those that are further away from it (we label them as bucket 2, or "B2"). We expect the former to be more constrained and hence if the reduction of borrowing is due to constrained demand then B1 banks would reduce borrowing more than B2 banks. However, if this pattern is not observed then the reduction is likely due to a supply shock, i.e. hedge funds reducing their lending. We create two dummy variables which classify the banks into the two groups, B1 and B2, and interact them with the variables. As can be seen in column (2), B1 banks significantly increased short-term borrowing during the stress period compared to the rest of 2020 (1.642) while long-term borrowing remained unaffected. In contrast, B2 banks reduced repo borrowing both on a short (-0.617) and long (-1.405) term basis. Hence, the results indicate that the overall reduction of long-term borrowing was due to a supply shock rather than a demand shock, as constrained banks did not reduce their activity.

To summarise, the analysis in this subsection reveals a substitution of long-term bank borrowing from dealers to investment funds, mainly concentrated in hedge funds, which can be fragile during times of stress. However, centrally cleared activity has increased and remains resilient even during times of stress. We further investigate participants' behaviour during stress in the next subsection.

5.2.2 Joint ratio constraints

In this subsection we examine hypotheses *H7* and *H8* on how potential joint ratio constraints can impact volumes and prices during times of stress. Since we focus on specific stress periods, we use SMMD which provides the necessary granularity at a daily frequency. Specifically, we focus on two stress episodes: the US repo turmoil in September 2019, and the Covid-19 market turmoil in March 2020. The former refers to an event of extreme volatility in the US repo market in the middle of September 2019, attributed to an idiosyncratic shock on the amount of central bank reserves in the financial system. The overnight repo rate reached 8% on September 17th which prompted the Federal Reserve to intervene to stabilise the market (BoE, 2019). While this shock did not originate in the UK repo market, Hüser et al. (2021) document significant spill-over effects. The latter stress event refers to the market turmoil due to Covid-19 which affected markets globally. The UK repo market experienced extreme volatility because the dealers were unable to accommodate a huge demand for cash due to regulatory constraints, which prompted the intervention of the Bank of England with the introduction of the Contingent Term Repo Facility on 24th March 2020 to stabilise the market (BoE, 2020). Hence, these two episodes provide an ideal environment to examine whether banks that were close to facing multiple constraints (simultaneously) reduced their activity to a greater extent.

In order to test our hypotheses, we use gilt repo transactions from SMMD at a daily frequency for two periods: from 15th August to 15th October 2019 for the US repo turmoil, and from 28th February to 30th April 2020 for the Covid-19 market turmoil. We then utilise a specification based on the first-order effects

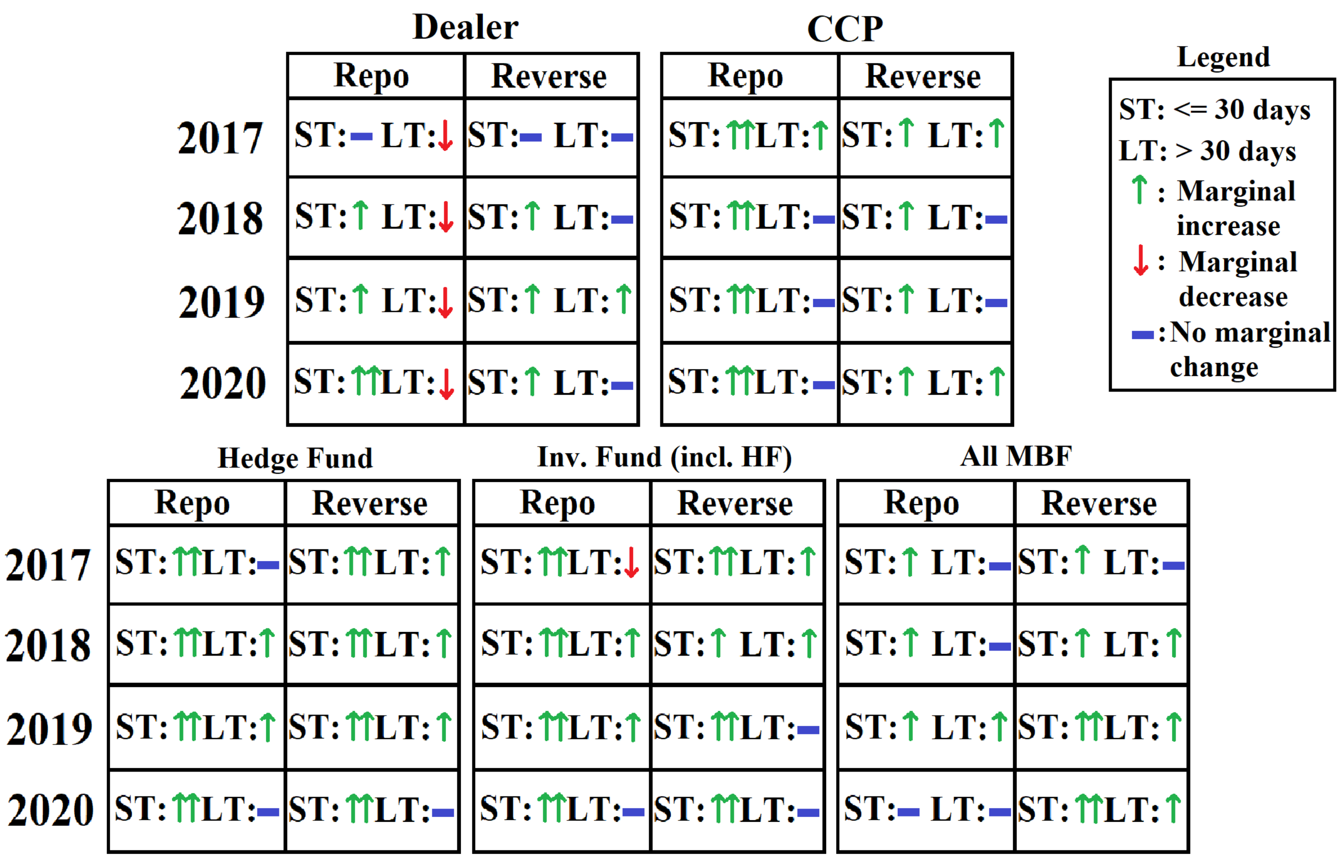

Figure 1: Evolution of banks' gilt repo borrowing and reverse repo lending by counterparty sector (SMMD). The figure shows yearly changes in volumes for short-term (ST) and long-term (LT) trades compared to 2016.

we documented in the previous subsection as described next.

5.2.2.1 Volumes

For volumes, we pool repo and reverse repo transactions together, and we expect the LR to constrain repo borrowing and the LCR to constrain reverse repo lending. It is important to note that while the LR is a binding capital requirement under all conditions, banks are expected to use their liquidity buffers during times of stress (PRA, 2020). Hence, if the banks were willing to allow their LCR to drop below 100%, it would not necessarily constrain their reverse repo activity. However, in practice banks prefer to retain their liquidity buffers even during times of stress, possibly due to market discipline, which would have an effect on their market activity.[18]

We calculate quantiles for each regulatory ratio as of the start of the sample period, and group participants into three categories: (i) those that enter the stress period being (close to) jointly constrained, i.e. both the LR and the LCR are in B1 (we label them as "Jointly constrained"); (ii) those that are constrained by a single ratio but not the other, either the LR or the LCR (we label them as "LR constrained" or "LCR constrained"); and (iii) those that are not constrained by either ratio, i.e. both being in B2 (we label them as "Not constrained"). We create dummy variables for each category and interact them with the ratios. We also create dummy variables for repo vs. reverse repo trades ("Repo" and "Reverse") and interact them with the LR and LCR respectively to isolate the effects of each ratio on the borrowing and lending segments of the market respectively. Finally we split trades into short-term and long-term ones as the effects can be expected to be stronger for long-term trades, which impose balance sheet costs for a longer period of time.

The results for volumes are presented in Table 6. In columns (1)-(2) we report results for general collateral and special collateral respectively for the US repo turmoil while in columns (3)-(4) we report corresponding results for the Covid-19 market turmoil. Looking at the effects of the LR on general collateral short-term repo borrowing trades during the US stress period in column (1), we observe that none of the coefficients is statistically significant, although they become increasingly negative when comparing banks that are not constrained, those that are constrained by the LR and those that are jointly constrained. However, the coefficients for long-term repo borrowing trades are significant and again become increasingly negative as banks become more constrained and bigger in absolute magnitude compared to short-term trades. Specifically, a 1% increase of the LR is associated with a decrease of volumes by 61.3%, 121.2% and 176.1% for non-constrained, LR-constrained and jointly constrained banks respectively. A similar pattern emerges for reverse repo activity. A 1% increase of the LCR decreases short-term reverse repo volumes by 1.5%, 2.3% and 4.2% for non-constrained, LCR-constrained and jointly constrained banks respectively,

[18] Huang and Takáts (2020) find that during the March 2020 market turmoil US commercial banks hoarded liquidity by doubling their cash assets.

Table 6: Gilt repo and reverse repo volumes and regulatory ratios during stress periods. This table reports estimates from OLS regressions of daily gilt general collateral and special collateral repo and reverse repo transaction volumes on the regulatory ratios using the SMMD dataset. Standard errors are double-clustered at the day and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from 15th August 2019 to 15th October 2019 for columns (1)-(2) and from 28th February 2020 to 30th April 2020 for columns (3)-(4).

Dependent Variable:	Log(Volume) (t)			
	(1) (GC US stress)	(2) (SC US stress)	(3) (GC Covid-19 stress)	(4) (SC Covid-19 stress)
CR (%) ($t-1$)	0.025	−0.115	−0.025	0.058
	(0.453)	(−1.291)	(−0.110)	(0.912)
LR (%) ($t-1$) * ST * Repo * Jointly constrained	−0.969	−1.249**	−0.843**	−0.298
	(−1.428)	(−2.718)	(−2.396)	(−0.563)
LR (%) ($t-1$) * ST * Repo * LR constrained	−0.675	0.347*	−0.208	0.238
	(−1.506)	(1.748)	(−0.612)	(1.084)
LR (%) ($t-1$) * ST * Repo * Not constrained	−0.275	0.161	−0.171	0.064
	(−1.130)	(1.200)	(−1.005)	(0.444)
LR (%) ($t-1$) * LT * Repo * Jointly constrained	−1.761**	−1.997***	−1.071***	−1.211***
	(−2.393)	(−4.588)	(−2.935)	(−3.079)
LR (%) ($t-1$) * LT * Repo * LR constrained	−1.212***	−0.594***	−0.708**	−0.736***
	(−2.873)	(−2.764)	(−2.487)	(−3.863)
LR (%) ($t-1$) * LT * Repo * Not constrained	−0.613*	−0.542***	−0.777***	−0.624***
	(−1.985)	(−4.088)	(−4.156)	(−4.451)
LCR (%) ($t-1$) * ST * Reverse * Jointly constrained	−0.042*	−0.042***	−0.037***	−0.012
	(−2.030)	(−2.861)	(−3.047)	(−0.733)
LCR (%) ($t-1$) * ST * Reverse * LCR constrained	−0.023*	0.006	−0.018**	0.002
	(−1.999)	(1.031)	(−2.246)	(0.335)
LCR (%) ($t-1$) * ST * Reverse * Not constrained	−0.015**	0.004	−0.012*	0.003
	(−2.168)	(1.372)	(−1.934)	(0.962)
LCR (%) ($t-1$) * LT * Reverse * Jointly constrained	−	−0.062***	−0.041***	−0.032**
	(−)	(−4.252)	(−3.253)	(−2.490)
LCR (%) ($t-1$) * LT * Reverse * LCR constrained	−0.031***	−0.020***	−0.022**	−0.023***
	(−2.878)	(−3.185)	(−2.559)	(−3.360)
LCR (%) ($t-1$) * LT * Reverse * Not constrained	−0.013**	−0.012***	−0.012*	−0.012***
	(−2.268)	(−3.411)	(−1.890)	(−3.796)
Intercept	22.282***	24.173***	22.686***	20.488***
	(12.732)	(12.408)	(6.678)	(20.090)
Day fixed effects	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	1,106	3,326	1,192	3,290
R^2	0.546	0.708	0.625	0.690

the latter two being marginally significant. Long-term trades are also affected, with a 1% increase of LCR being associated with a decrease of 1.3% and 3.1% of reverse repo activity for non-constrained and LCR-constrained banks respectively. The coefficient for jointly constrained banks is omitted because there are no such trades occurring during the stress period, which indicates a complete market freeze of general collateral long-term reverse repo lending by jointly constrained banks.

Focusing on special collateral trades during the US stress period in column (2), we observe a significant effect of the LR on short-term repo borrowing for jointly constrained banks only, with a 1% increase of the LR associated with a decrease of activity by 124.9%. Long-term repo borrowing trades are affected even more, with volumes decreasing by 54.2%, 59.4% and 199.7% for non-constrained, LR-constrained and jointly constrained banks respectively. On reverse repo lending, jointly constrained banks reduce short-term activity by 4.2% for every 1% increase of LCR, while long-term trades are reduced by 1.2%, 2% and 6.2% by non-constrained, LCR-constrained and jointly constrained banks respectively.

Moving to the Covid-19 stress period and focusing on general collateral trades in column (3), we again observe increasingly negative coefficients on the effect of the LR on short-term repo borrowing trades, although only jointly constrained banks are significantly affected, with a 1% increase of LR being associated with a decrease of activity by 84.3%. Long-term repo borrowing trades are affected across all groups, with negative coefficients of 77.7%, 70.8% and 107.1% for non-constrained, LR-constrained and jointly constrained banks respectively. Short-term reverse repo lending is similarly affected by an increase of LCR, with volume decreases of 1.2%, 1.8% and 3.7% by non-constrained, LCR-constrained and jointly constrained banks respectively. The decreases are slightly larger for long-term trades, 1.2%, 2.2% and 4.1% for non-constrained, LCR-constrained and jointly constrained banks respectively.

Finally, on special collateral trades during the Covid-19 stress period in column (4), the LR does not significantly impact short-term repo trades but it does long-term trades, with a 1% increase being associated with a decrease of activity by 62.4%, 73.6% and 121% for non-constrained, LR-constrained and jointly constrained banks respectively. Short-term reverse repo lending trades are similarly unaffected by LCR, but long-term trades decrease by 1.2%, 2.3% and 3.2% for non-constrained, LCR-constrained and jointly constrained banks respectively.

The results validate *H7* and provide several insights on participants' behaviour during times of stress. **First**, the regulatory ratios can have a non-linear impact on market activity as jointly constrained banks reduce their activity to a much higher extent than singly constrained or non-constrained ones. **Second**, the impact is more acutely felt on long-term trades because the participants are unwilling to carry the balance sheet cost for long periods of time.[19]

[19] In order to further investigate the role of regulatory buffers in driving our results, we conducted a difference-in-differences

5.2.2.2 Prices

For prices, we again pool repo and reverse repo transactions together, and we expect that participants who are constrained by the LR will have a stronger reaction to prices compared to non-constrained ones. Hence, we group participants into two categories: (i) those that are constrained by the leverage ratio, i.e. being in the B1 group (we label them as "Constrained"); and (ii) those that are not constrained, i.e. being in the B2 group (we label them as "Not constrained"). We also use the dummy variable "Non-netted" and multiply it with the LR to assess any relevant differential effects compared to netted trades which form the baseline as in subsection 5.1.2.

The results are reported in Table 7. When looking at general collateral trades during the US stress episode in column (1), we observe that non-constrained banks imposed 0.8 bps lower rates for non-netted short-term repo borrowing trades compared to the corresponding netted ones for every 1% increase of the LR, and 0.9 bps lower for the long-term ones. However, they also lent in non-netted short-term and long-term reverse repo trades at lower rates compared to the corresponding netted ones by 0.5 bps and 0.9 bps respectively. In addition, constrained banks stopped conducting entirely non-netted long-term borrowing trades, as well as both netted and non-netted long-term lending as indicated by the omitted coefficients. In other words, while constrained banks stepped out of lending in long-term maturities, non-constrained ones stepped in and provided liquidity. On special collateral trades in column (2), constrained banks charged 0.9 bps higher interest on non-netted short-term reverse repo lending trades compared to netted ones, and even more so on corresponding long-term ones (2.1 bps). Similarly, non-constrained banks charged 1.3 bps higher interest on non-netted long-term reverse repo lending trades compared to netted ones.

Moving to the Covid-19 stress episode, for general collateral trades in column (3), while there was no significant difference between netted and non-netted trades overall, it is interesting to observe that both constrained and non-constrained banks stepped out of non-netted long-term repo borrowing and reverse repo lending as indicated by the omitted coefficients. In other words, during this stress episode, banks preferred to participate in short-term maturities only or in long-term trades that were nettable in order to avoid the balance sheet cost. Finally, when looking at special collateral trades in column (4), non-constrained banks imposed a 0.6 bps lower interest on non-netted short-term repo borrowing trades compared to netted ones and a 4.1 bps higher interest on non-netted long-term reverse repo lending trades compared to netted ones. At the same time, constrained banks imposed a 1.9 bps higher interest on non-netted short-term reverse repo lending trades compared to netted ones. Overall, the results indicate that during times of

analysis where we examined the volumes of UK banks (treatment group) compared to other banks (control group) before and after the UK CCyB release on 11th March 2020. We restricted the sample until 17th March 2020 to exclude other countries' CCyB releases after that. The analysis shows that UK banks significantly increased their special repo activity following the CCyB release compared to other banks, which indicates that the larger headroom capital allowed them to intermediate more.

stress, banks may charge higher interest compared to normal times on non-nettable trades or completely step out of such trades on long-term maturities which are more likely to be conducted with end-clients, consistent with *H8*. These results corroborate and expand on those of a case study examining the behaviour of UK dealers during the Covid stress episode, which found that they increased the price differential between netted and non-netted repo trades compared to normal times (BCBS, 2021).

5.3 Further robustness analysis

5.3.1 Regional effects

To validate our previous findings, we run some additional checks along a number of dimensions. First, we examine whether participants' jurisdiction affects their activity. In particular, we wish to see whether opportunities for regulatory arbitrage or home rule legislation may undermine our previous findings. We group the participants according to the region that their headquarters are based in, into Asia, EU, UK and US and we repeat the analysis reported in Tables 1 - 3 adding this dimension. The results for repo borrowing volumes are reported in Table D1 in Appendix D where we use UK banks as the baseline, and all other regions are expressed as relative to UK banks. From column (1), for general collateral repo borrowing trades backed by gilts the coefficient for the LR is negative and marginally significant for UK banks, while for US banks it is positive, significant and similar in magnitude, indicating that US banks are not constrained by the LR for these trades. When looking at special collateral repo borrowing trades backed by gilts in column (2), none of the LR coefficients are significant but the effect documented in Table 1 is driven by EU banks which have the largest difference with UK banks. Repo borrowing holdings backed by gilts show a negative but insignificant coefficient for UK banks in column (3), and positive, insignificant and similar in magnitude for all other regions. Finally, when looking at repos backed by lower-quality collateral including L2A, L2B and other collateral in column (4), the CR coefficient is negative and marginally significant for UK banks while for Asian banks it is positive, significant and similar in magnitude, indicating that Asian banks are not constrained by the CR for these trades.

Table 7: Gilt repo and reverse repo excess rates and regulatory ratios during stress periods. This table reports estimates from OLS regressions of daily gilt general collateral and special collateral repo and reverse repo transaction excess rates on the regulatory ratios using the SMMD dataset. Standard errors are double-clustered at the day and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from 15th August 2019 to 15th October 2019 for columns (1)-(2) and from 28th February 2020 to 30th April 2020 for columns (3)-(4).

Dependent Variable:	Excess rate (Repo rate - Bank rate) (%) (t)			
	(1) (GC US stress)	(2) (SC US stress)	(3) (GC Covid-19 stress)	(4) (SC Covid-19 stress)
CR (%) ($t-1$)	0.018**	−0.015	0.010	0.008
	(2.574)	(−1.527)	(0.700)	(1.098)
LCR (%) ($t-1$) * ST	0.000	0.000	−0.000	−0.001
	(1.307)	(0.750)	(−0.589)	(−1.308)
LCR (%) ($t-1$) * LT	0.000*	0.000	0.000	−0.000
	(1.804)	(0.866)	(0.109)	(−0.587)
LR (%) ($t-1$) * ST * Repo * Constrained	−0.009	0.005	−0.075*	−0.026
	(−0.693)	(0.131)	(−2.019)	(−1.045)
LR (%) ($t-1$) * ST * Repo * Constrained * Non-netted	−0.002	−0.004	0.004	0.000
	(−0.983)	(−1.422)	(1.128)	(0.020)
LR (%) ($t-1$) * LT * Repo * Constrained	−0.006	0.012	−0.066	−0.019
	(−0.415)	(0.335)	(−1.634)	(−0.633)
LR (%) ($t-1$) * LT * Repo * Constrained * Non-netted	−	−0.003	−	−0.012
	(−)	(−0.862)	(−)	(−0.531)
LR (%) ($t-1$) * ST * Repo * Not constrained	0.002	0.049	−0.053	−0.034
	(0.082)	(1.081)	(−1.371)	(−0.808)
LR (%) ($t-1$) * ST * Repo * Not constrained * Non-netted	−0.008***	0.003	−0.003	−0.006*
	(−3.070)	(1.148)	(−1.064)	(−1.969)
LR (%) ($t-1$) * LT * Repo * Not constrained	0.003	0.052	−0.036	−0.057
	(0.098)	(1.105)	(−0.857)	(−1.280)
LR (%) ($t-1$) * LT * Repo * Not constrained * Non-netted	−0.009**	−0.000	−	0.014
	(−2.561)	(−0.031)	(−)	(1.490)
LR (%) ($t-1$) * ST * Reverse * Constrained	−0.006	0.003	−0.060	−0.029
	(−0.453)	(0.074)	(−1.662)	(−1.163)
LR (%) ($t-1$) * ST * Reverse * Constrained * Non-netted	−0.001	0.009***	−0.004	0.019***
	(−0.296)	(3.516)	(−1.284)	(4.688)
LR (%) ($t-1$) * LT * Reverse * Constrained	−	0.017	−0.078*	0.007
	(−)	(0.490)	(−1.826)	(0.247)
LR (%) ($t-1$) * LT * Reverse * Constrained * Non-netted	−	0.021***	−	0.010
	(−)	(4.898)	(−)	(0.505)
LR (%) ($t-1$) * ST * Reverse * Not constrained	0.005	0.046	−0.047	−0.036
	(0.161)	(0.999)	(−1.219)	(−0.844)
LR (%) ($t-1$) * ST * Reverse * Not constrained * Non-netted	−0.005*	0.008	0.000	0.003
	(−1.751)	(1.565)	(0.113)	(1.019)
LR (%) ($t-1$) * LT * Reverse * Not constrained	0.003	0.065	−0.041	−0.051
	(0.098)	(1.427)	(−0.972)	(−1.097)
LR (%) ($t-1$) * LT * Reverse * Not constrained * Non-netted	−0.009**	0.013***	−	0.041***
	(−2.530)	(5.979)	(−)	(5.614)
Intercept	−0.317*	0.029	0.184**	0.099
	(−2.049)	(0.269)	(2.305)	(0.728)
Day fixed effects	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	1,173	3,752	1,296	3,648
R^2	0.445	0.601	0.525	0.582

To complement, we turn to reverse repo lending volumes. The results are presented in Table D2 in Appendix D. On general collateral reverse repos backed by gilts in column (1), the baseline UK LCR coefficient for long-term trades is negative and marginally significant, while for Asian banks it is positive, significant and similar in magnitude indicating that Asian banks are not constrained by the LCR for these trades. All other regions have insignificant coefficients indicating similar magnitude as the UK banks. On special collateral reverse repos backed by gilts in column (2), the baseline UK LCR coefficient for short-term trades is positive and marginally significant, while for all other regions it is insignificant indicating no differences with UK banks. LCR coefficients in reverse repo holdings backed by gilts are insignificant in column (3) consistent with the results of Table 3. Finally, the baseline UK LCR coefficients for short and long-term holdings backed by lower-quality collateral in column (4) are negative and marginally significant, while for Asian and US banks they are positive and similar in magnitude indicating that the LCR mainly constrains UK and EU banks for these holdings.

5.3.2 Collateral shocks

Second, we expand our baseline first-order investigation by analysing the effects of collateral price movements on our main results. Specifically, we focus on gilt special collateral trades for which the security pledged is known and combined with the securities' daily prices. We calculate a daily collateral "portfolio" weighted average return for each participant, where the weights are the volumes for each transaction and the returns are the daily securities' returns. This gives us a portfolio counterfactual. Finally we aggregate to a quarterly frequency by taking the average of the daily portfolio returns.

We speculate that a participant's activity will become more constrained when there is a high volatility in the return of the portfolio of collateral securities backing the repo transactions which could have a negative effect on their regulatory ratios. In order to test this assumption, we create a dummy variable called "Shock" that takes the value of 1 for transactions where the average portfolio return is larger than one standard deviation of its distribution. Transactions where the return is smaller than one standard deviation are classified according to the dummy variable "No shock". We further split participants into two groups, B1 and B2, according to the quantile of the regulatory ratio where they belong using the entire sample, as B1 banks are more likely to be affected by market volatility than B2 ones since they are closer to the regulatory threshold.

The results are presented in Table E1 in Appendix E. Looking at gilt repo borrowing trades in column (1), we note that the LR has the largest impact on B1 banks (-1.193) in more volatile trades (Shock), followed by B2 banks (-0.807). We do not find an impact on less volatile trades (No shock). The LCR also has a restraining impact on long-term trades, albeit higher for less volatile trades, with B1 banks having a slightly larger impact (-0.012) compared to B2 ones (-0.011). Turning to reverse repo lending trades in column (2), a similar pattern emerges. The LR has an impact on both less volatile and more volatile trades, although admittedly the coefficients are, in absolute terms, larger for the more volatile trades (B1: -0.364, B2: -0.260) compared to the less volatile ones (B1: -0.232, B2: -0.210), and even more so for B1 banks compared to B2 ones. The LCR has no impact on long-term more volatile trades, but it does on the less volatile ones, with B1 banks again having a slightly larger impact (-0.006) compared to B2 ones (-0.005).

Overall, the results indicate that the LR is more likely to bind when market volatility is high and participants are closer to their regulatory thresholds. In contrast, the LCR is more likely to restrict long-term trades during low market volatility, which could be related to participants' avoidance of these trades as they build up their HQLA stock as part of their strategy to increase their LCR buffers during normal times.

5.3.3 Alternative volumes aggregation

Finally, we provide robustness results using alternative definitions of volumes. In the baseline regressions, we used aggregate volumes per quarter and bank since the regulatory ratios are typically reported at quarterly frequency. Therefore, these ratios could either capture end-of-quarter activity or daily averaging over the previous quarter, depending on the requirements of each jurisdiction. To prevent biases or mismeasurement issues, we extend the baseline repo and reverse repo results based on volumes on the first day after each quarter-end, the last day before each quarter-end, as well as the mean volume over each quarter. The results are presented in Tables F1 - F6 in Appendix F. In general, the extended results are consistent with our main story. The LR constrains repo borrowing backed by gilts for general collateral trades when using the first or last day volumes, and for both general and special collateral when using the average volumes. The CR constrains repo borrowing backed by lower-quality collateral (L2B using first day volumes, other using last day volumes and L2A using average volumes). The LCR constrains long-term reverse repo lending backed by lower-quality collateral and long-term repo borrowing backed by gilts, where significant.

6 Conclusion and policy implications

Using unique datasets of UK repo transactions and holdings, we conduct a comprehensive investigation of repo activity under Basel III across different collateral segments and institutions. First, we study the first-order effects of the leverage ratio, the capital ratio and the liquidity coverage ratio on repo and reverse repo volumes backed by gilts and lower-quality collateral. In addition, we examine the effects of the LR on the prices of netted and non-netted trades. Second, we examine the higher-order effects of the regulation on the long(er)-term market structure and market behaviour under stress.

The study provides several important insights. First, we document differential effects of each regulatory ratio on different segments of the repo market. Specifically, we find that the leverage ratio impacts participants conducting repo borrowing backed by gilts while the capital ratio constrains participants conducting repo borrowing backed by lower-quality collateral. The liquidity coverage ratio constrains participants conducting long-term reverse repo lending as well as collateral swap trades and reduces incentives to conduct long-term repo borrowing backed by gilts. In addition, the leverage ratio induces differential prices between netted and non-netted trades. Banks request lower rates when conducting non-nettable repo borrowing trades compared to nettable ones, and higher rates when conducting non-nettable reverse repo lending trades compared to nettable ones. Second, we find that banks substitute long-term repo borrowing from dealers to investment funds, mainly hedge funds, but the latter are prone to reduce their lending during times of stress, proving a fragile source of funding. Finally, during stress periods banks that are (close to) being jointly constrained by the leverage ratio and the liquidity coverage ratio reduce their repo borrowing and reverse repo lending activity to a greater extent than those that are constrained by a single ratio and even more than those that are unconstrained. The leverage ratio also has a greater impact on prices during stress periods compared to normal times.

Our conclusions provide important evidence relevant for the debate on the post-GFC banking reforms. In particular, this study sheds light on the wider effects these reforms have had on UK repo market activity. This market is a key source of funding for financial institutions and critical for the transmission of monetary policy. The Covid-19 stress episode in March 2020 highlighted the need to examine the resilience of liquidity suppliers in the repo market (BoE, 2021a). Our results contribute to this goal by showcasing the impact of each regulatory ratio on banks' intermediation capacity in different segments of the market. Moreover, we study how these participants adjust their behaviour under stress when their joint ratios are approaching the regulatory thresholds. Furthermore, by showcasing that the leverage ratio can have a differential effect on prices of netted vs. non-netted trades, which increases during times of stress, our results contribute to the discussion on the future structure of the repo market and the beneficial effects of greater central clearing (BoE, 2021a). However, our results also highlight other developments in market microstructure such as the migration of long-term repo borrowing of banks from dealers to investment funds, which may not be resilient during times of stress as hedge funds step out of the market (BoE, 2021b). Hence, our paper echoes the need to track these structural shifts and contributes with evidence to the wider ongoing regulatory assessment, including whether the regulatory perimeter should be expanded or calibrated.

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A Basel III implementation timeline

In Figure A1, we summarise the implementation timeline for three out of the four regulatory ratios considered in this study. The net stable funding ratio has yet to be formally implemented in most jurisdictions so we do not examine it, although its impact on the repo market is likely to be significant when it becomes binding (ICMA, 2016). For the UK, it is scheduled to be introduced on 1st January 2022.

Regarding the leverage ratio, the Basel III accords recommended that banks should report it to the regulatory authorities from 2013, while from 2015 it should be publicly disclosed and from 2018 it should become binding with a minimum threshold of 3%. The EU formally introduced it as a binding regulatory requirement in 2019. Japan mandated a public disclosure from March 2015, making it a binding requirement from March 2019 with a minimum threshold of 3%. The UK made the leverage ratio a binding requirement in 2016, and further amended the minimum threshold to 3.25% in 2017 because it excluded central bank claims such as reserves and cash in pound sterling (PRA, 2017). However, it is important to note that this applies for banks (and building societies) with retail deposits of at least £50 billion, and for ring-fenced bodies belonging to groups containing such banks. From 1st January 2023, the leverage ratio requirement will apply to all firms with retail deposits of at least £50 billion or foreign assets of at least £10 billion, which would include most bank dealers.[20] Even though these entities may not have a leverage ratio requirement in our sample period, they are still likely to be affected by the parent leverage ratio which would drive the behaviours we document (Allahrakha et al., 2018; Duffie, 2018). Finally, the US mandated the public disclosure of the leverage ratio requirement in 2015, becoming binding in 2018. Furthermore, the minimum threshold was increased to 5% for the global systemically important banks (US G-SIBs).

On the capital ratio, Basel III recommended an increase of the minimum threshold of common equity tier 1 capital (CET1) as a fraction of total risk-weighed assets to 4.5%. Similarly, the Tier 1 capital ratio increased to 6%, while the capital adequacy ratio (Tier 1 + Tier 2 capital) increased to 8%. In addition to these core ratios, banks were required to hold additional buffers such as the capital conservation buffer at 2.5% of risk weighted assets while the systemic banks were also required to hold the systemic risk buffer. Regulatory authorities also have the discretion of applying the countercyclical capital buffer (CCyB) to counteract the procyclical nature of the credit cycle by ensuring that banks have available capital to lend during times of stress.

Finally, on the liquidity coverage ratio, Basel III recommended a gradual implementation, with the minimum threshold increasing from 60% in 2015 to 100% in 2019. The EU implemented the minimum threshold of 60% in October 2015 under the Capital Requirements Directive IV (CRD IV), which also

[20] https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/policy-statement/2021/october/ps2121.pdf

became binding for the UK. The liquidity coverage ratio became fully phased-in in January 2018, with a minimum threshold of 100%. Japan introduced a minimum threshold of 60% in March 2015, increasing it to 100% in March 2019 in line with the Basel III recommendations. The US introduced a minimum threshold of 80% in 2015, increasing to 100% in 2017.

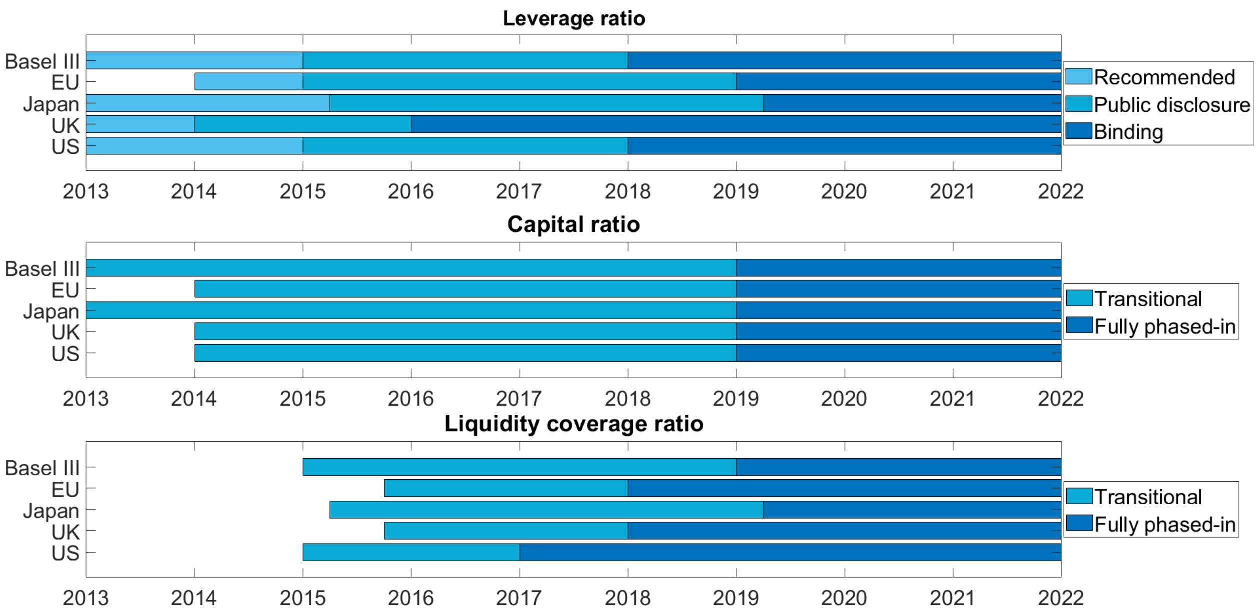

Figure A1: Basel III ratios implementation timeline

B Data description

In Figure B1, we plot the evolution of the UK gilt repo market using SMMD, splitting total monthly volume by GC and SC trades. As can be seen, since 2016 there has been an increase in market activity, mainly SC trades, which constitute 95% of transactions and 83% of total transactions volume. In Figure B2 we decompose total transactions volume by maturity buckets, less than or equal to 30 days, and more than 30 days. The graph shows that the majority of trades have a maturity of less than 30 days (97% of transactions and total volume). In Figure B3 we decompose total volume by participants' headquarters region. As is to be expected, UK-domiciled banks dominate the market in terms of traded volumes (32% of transactions and 40% of total volume), followed by US-domiciled banks (36% of transactions and 33% of total volume), EU-domiciled banks (24% of transactions and 20% of total volume) and Asia-domiciled banks (8% of transactions and 7% of total volume). Overall, on a monthly basis transaction volumes have doubled from £2 trillion in 2016 to £4 trillion in November 2020 which highlights the significance of repos as a key funding market in the UK.

To give perspective, we also report the gilt repo and reverse repo *holdings* separated across maturity and region, as share of the total market. As can be seen, short-term holdings constitute 54% of the total, indicating that while they represent the vast majority of transactions since they roll-over much more frequently, they are roughly equal to long-term repo and reverse repo holdings. Expressed differently, while in terms of flows (or volumes), short-term clearly dominates long-term, in terms of stocks (or holdings), the two are relatively equal. Furthermore, UK banks hold 45% of the total volume, followed by US banks with 35%, EU banks with 14% and Asian banks with 6%.

Moving to PRA110, in Figure B5 we plot the repo and reverse repo holdings by collateral type of the selected institutions. The reporting of L1 holdings started in January 2020, in contrast to other types of collateral which started in July 2019. The monthly holdings of repos and reverse repos backed by L1 collateral are the largest by value, averaging £20 trillion but increasing markedly towards the end of the year to more than £25 trillion. Of this amount, around £5 trillion is comprised of gilt repos and reverse repos, while the rest is backed by other government bonds. L2A and L2B collateral-backed repos and reverse repos range between £1 trillion and £2 trillion, while those backed by non-HQLA ("other") securities range between £3 trillion and £4.5 trillion.

In Figure B6 we similarly plot the collateral swap holdings by collateral type of the selected institutions, which include both inflows (i.e. where the security of the specified collateral type is received) and outflows (i.e. where the security of the specified collateral type is given). Swap holdings involving the exchange of L1 collateral average £2 trillion but increase to £2.6 trillion towards the end of 2020, while those involving

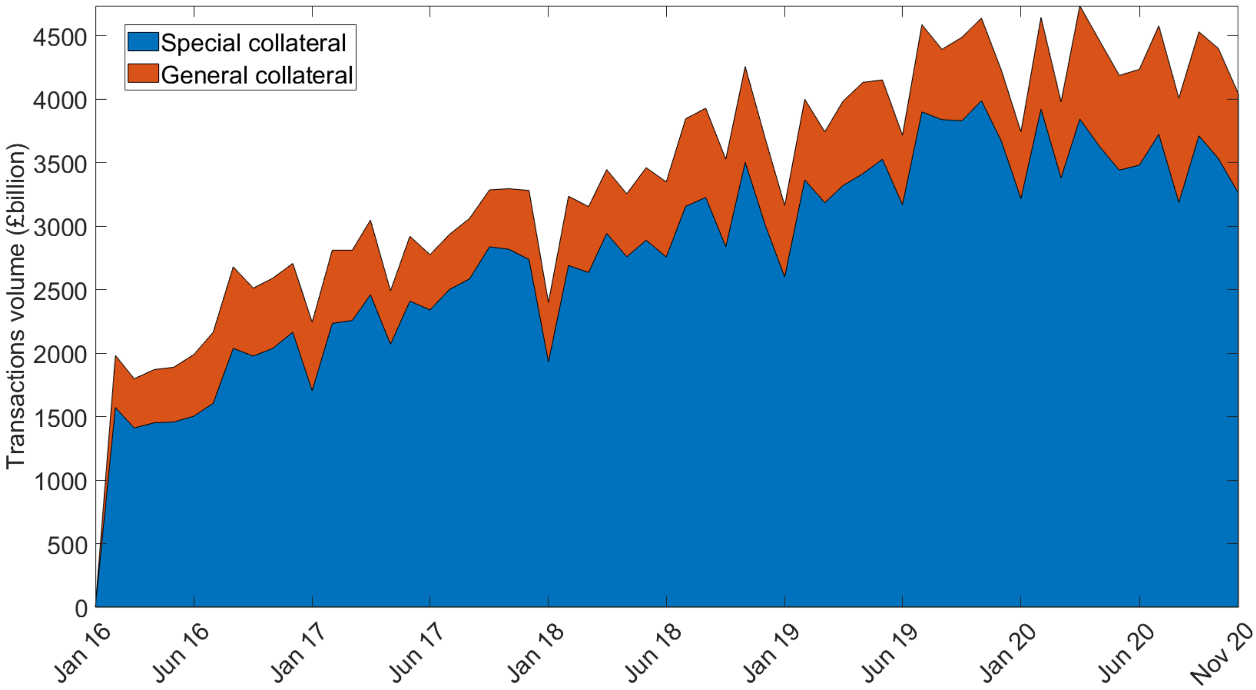

Figure B1: Monthly gilt repo and reverse repo transaction volumes by collateral type (SMMD)

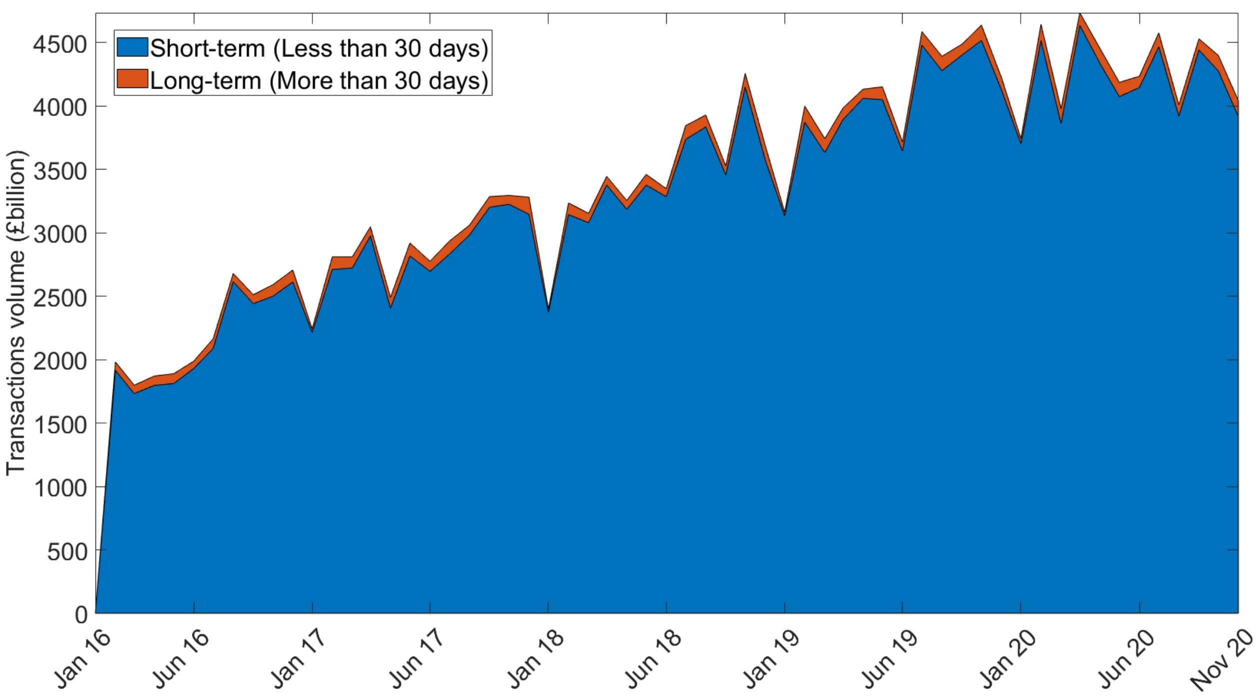

Figure B2: Monthly gilt repo and reverse repo transaction volumes by maturity bucket (SMMD)

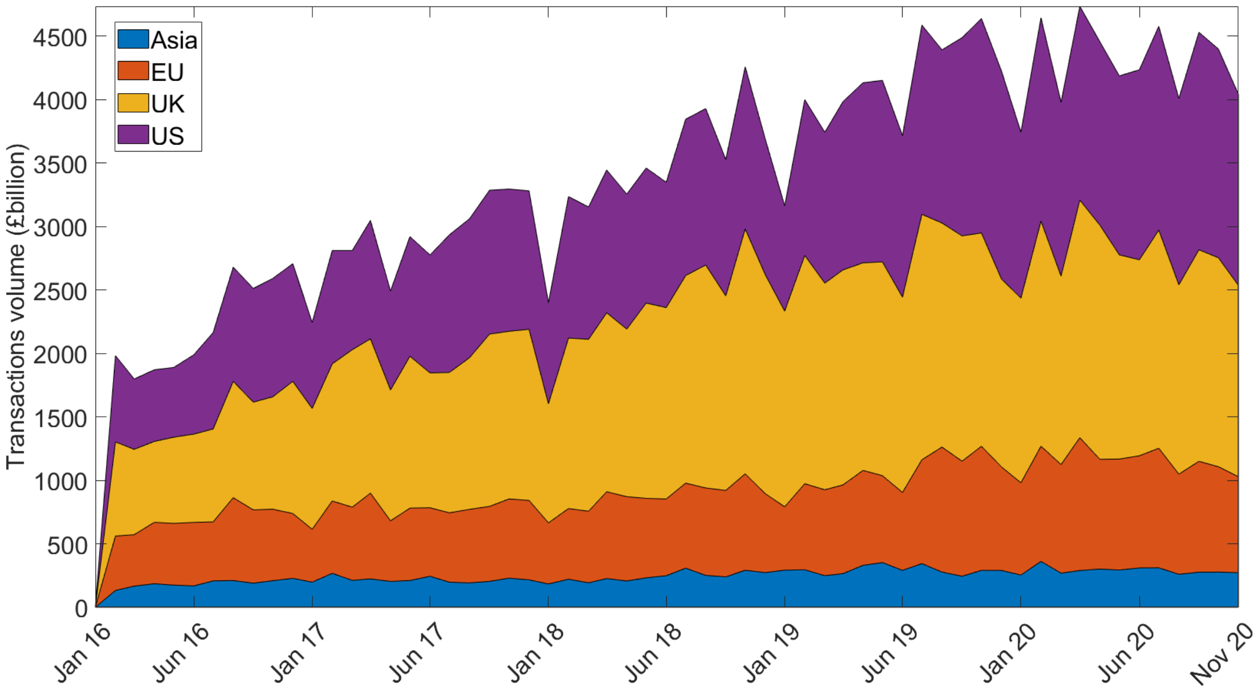

Figure B3: Monthly gilt repo and reverse repo transaction volumes by region (SMMD)

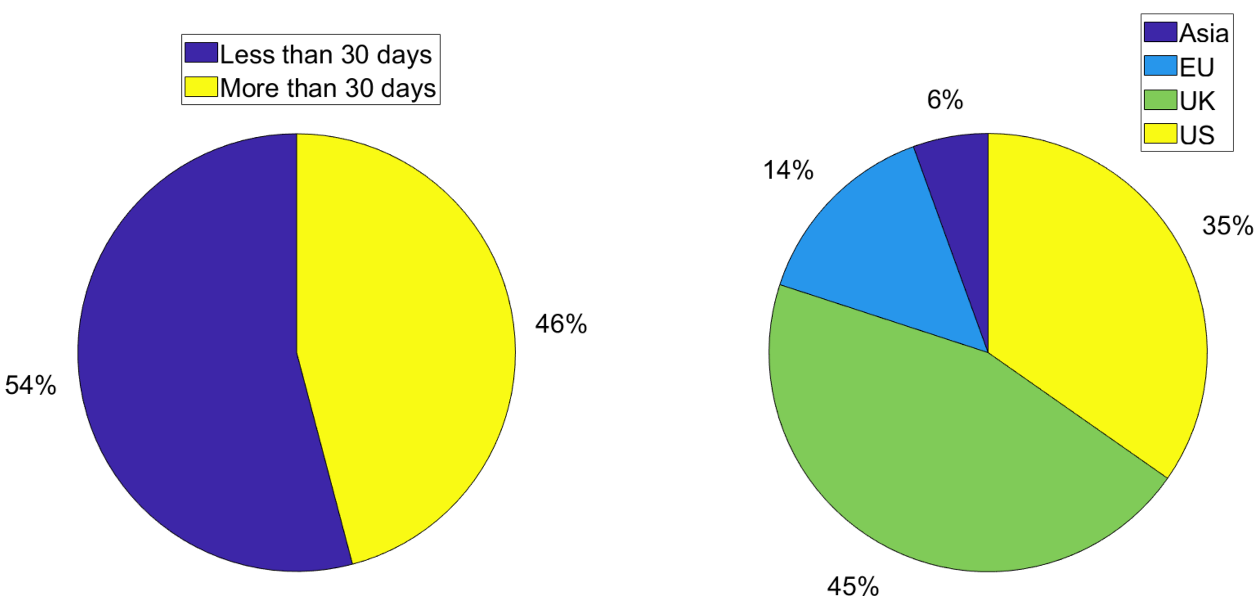

Figure B4: Gilt repo and reverse repo holdings volumes by maturity bucket and region (SMMD)

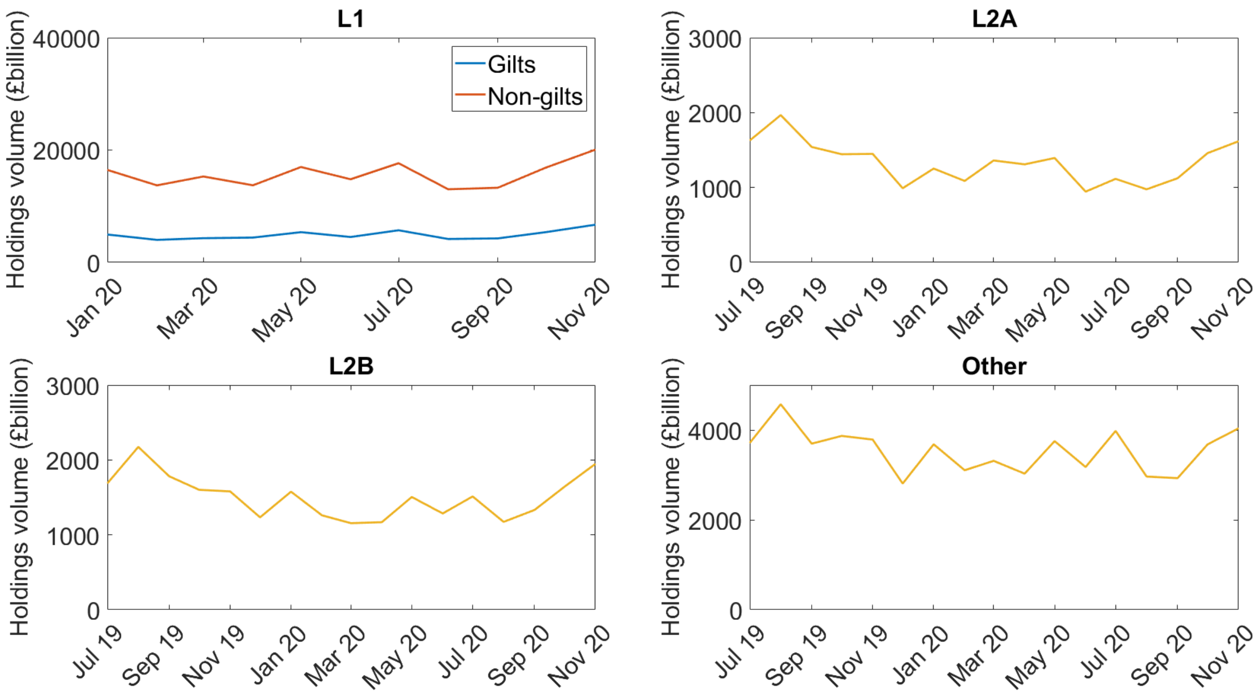

Figure B5: Monthly repo and reverse repo holdings by collateral quality (PRA110)

specifically gilts average £10 billion but increase to £15 billion towards the end of 2020. Swap holdings involving the exchange of L2A and L2B collateral range between £500 billion and £1 trillion, while those involving the exchange of other collateral average £1 trillion. Overall, while smaller than the repo holdings, banks hold a sizeable amount of collateral swaps.

In Table B1 we provide descriptive statistics of the variables we use in this study. We report the aggregate statistics although the underlying is calculated at the institution level, and volumes and prices are reported at daily and quarterly frequencies as both are used in our analysis. In Panel A, the descriptive statistics of the regulatory ratios for the sample of institutions used in this study are presented. The LR is on average 4.69%, with a 5th percentile value of 3.08% and a 95th percentile value of 6.57%. The Tier 1 CR is on average 16.39%, ranging from 11.90% to 22.98%. Finally, the LCR is on average 156.94%, ranging from 117.90% to 256.23%. Overall, we note that banks have adjusted their ratios to above the minimum regulatory thresholds from as early as 2016 since they have preferred to hold significant buffers possibly due to market discipline.

In Panel B, descriptive statistics for daily and quarterly transaction volumes from SMMD and for quarterly holdings volumes from PRA110 are provided. The two databases are not directly comparable as SMMD reports transactions while PRA110 reports holdings, so the latter's volumes are larger. Looking at SMMD, on a daily frequency, the average general repo transaction volume across institutions is £1,542.68 million, while the average general reverse repo transaction volume is £469.48 million. On a quarterly frequency, the corresponding mean volumes are £51,328.04 million and £10,654.75 million. Special collateral transaction

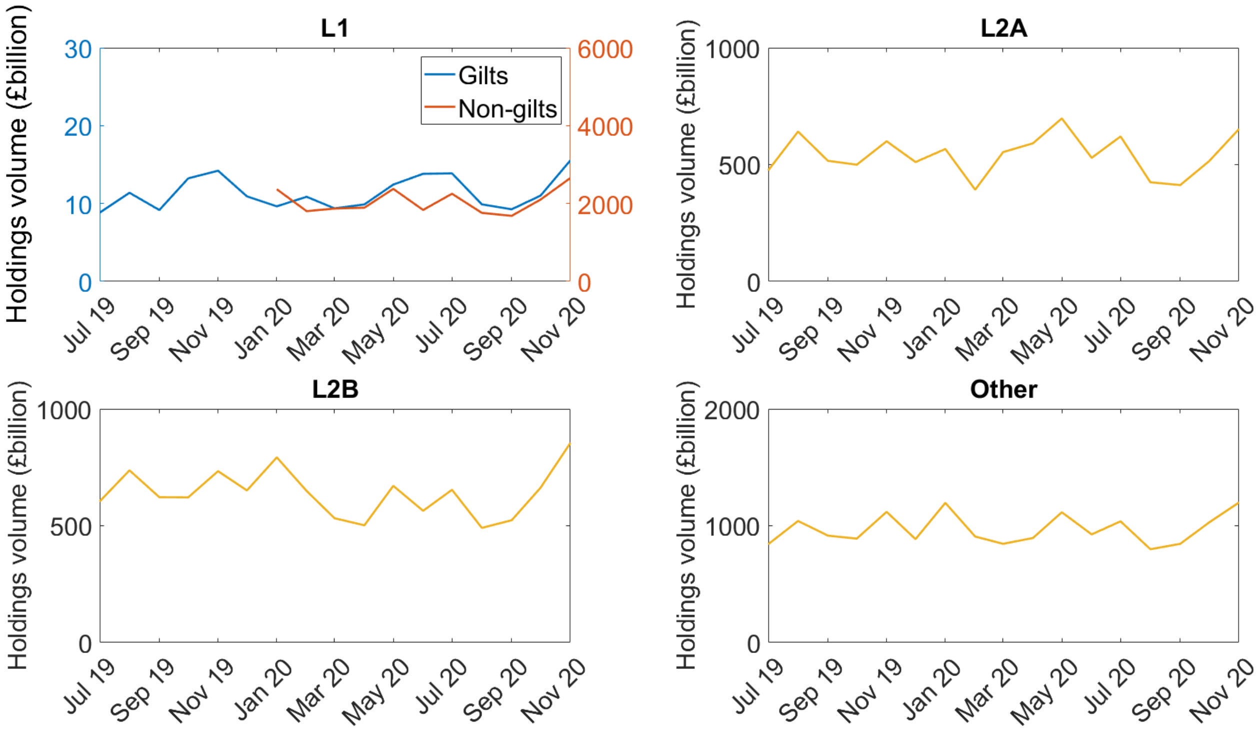

Figure B6: Monthly collateral swap holdings by collateral quality (PRA110)

volumes follow a similar pattern, with daily average repo volumes being £2,333.68 million and reverse repo volumes being £1,728.02 million. On a quarterly frequency they average £91,351.56 million and £78,072.54 million. Overall, the higher volumes in repo compared to reverse repo transactions corroborates previous findings that banks and dealers are net borrowers in the UK repo market (Hüser et al., 2021).

Next, looking at PRA110 holdings volumes, the average L1 gilt repo holdings volume is £163,485.58 million, L2A volume is £47,017.69 million, L2B volume is £31,373.65 million and other volume is £143,254.32 million. On reverse repo holdings, L1 gilt volume is on average £196,391.16 million, L2A volume is £68,582.80 million, L2B volume is £65.481.01 million and other volume is £148,417.60 million. When looking at collateral swap holdings volumes, L1 gilt inflows are on average £1,049.12 million, L2A inflows are £9,891.60 million, L2B inflows are £17,257.65 million and other inflows are £29,052.43 million. L1 gilt outflows are on average £1,868.61 million, L2A outflows are £46,586.96 million, L2B outflows are £45,197.87 million and other outflows are £58,229.11 million. Overall, swap outflows volumes are larger than the corresponding inflows.

Finally, in Panel C descriptive statistics for repo prices from SMMD are presented. We report the excess rate, which is the repo rate minus the Bank rate. On a daily frequency, the average general repo excess rate is −0.037%, ranging from −0.130% to 0.050%. The average general reverse repo excess rate is −0.001%, ranging from −0.105% to 0.100%. When averaging daily excess rates on a quarterly frequency, the mean general repo rate is -0.016%, ranging from -0.100% to 0.074%, while the mean general reverse repo rate is 0.010%, ranging from -0.077% to 0.114%. On special collateral, the daily average repo excess rate is -0.066%, ranging from -0.178% to 0.020%, while the daily average reverse repo excess rate is 0.012%, ranging from -0.135% to 0.260%. On a quarterly frequency, the average repo excess rate is -0.062%, ranging from -0.154% to 0.020%, while the average reverse repo excess rate is 0.008%, ranging from -0.136% to 0.213%. Overall, we observe that special collateral rates are more negative than those of general collateral because demand in the former is driven by cash lenders who are searching for collateral.

Table B1: Summary statistics for the variables used in the study. Columns denote, respectively, the name of the variable, number of observations, mean value, standard deviation, 5th, 25th, 50th, 75th and 95th percentiles.

Variable	*N*	Mean	SD	5th	25th	50th	75th	95th
Panel A: Basel III ratios								
Leverage ratio (%)	2,065	4.69	1.05	3.08	4.10	4.48	5.24	6.57
Tier 1 capital ratio (%)	2,065	16.39	4.03	11.90	13.63	16.10	17.79	22.98
Liquidity coverage ratio (%)	1,988	156.94	46.37	117.90	127.00	140.00	160.97	256.23
Panel B: Volumes								
Daily gilt general repo volumes (SMMD) (£million)	18,889	1,542.68	1,877.62	50.00	295.00	897.60	1,942.00	5,642.91
Daily gilt general reverse repo volumes (SMMD) (£million)	10,935	469.48	576.74	26.00	106.00	261.50	600.00	1,588.60
Quarterly general gilt repo volumes (SMMD) (£million)	541	51,328.04	92,004.69	192.00	1,556.50	8,284.00	62,208.37	251,995.64
Quarterly general gilt reverse repo volumes (SMMD) (£million)	463	10,654.75	16,349.69	105.49	1,099.00	3,740.86	12,909.40	45,922.63
Daily gilt special repo volumes (SMMD) (£million)	34,604	2,333.68	2,481.80	28.00	299.40	1,484.96	3,696.82	7,308.00
Daily gilt special reverse repo volumes (SMMD) (£million)	41,069	1,728.02	2,261.74	16.64	130.72	670.63	2,737.77	6,221.15
Quarterly special gilt repo volumes (SMMD) (£million)	884	91,351.56	132,245.78	179.71	1,601.55	11,124.59	161,544.58	367,737.83
Quarterly special gilt reverse repo volumes (SMMD) (£million)	909	78,072.54	121,730.26	333.95	3,650.20	12,218.18	106,046.15	343,949.91
Quarterly L1 (gilt) repo volumes (PRA110) (£million)	115	163,485.58	153,663.68	2,421.36	33,219.67	121,632.16	229,278.04	467,801.65
Quarterly L2A repo volumes (PRA110) (£million)	162	47,017.69	87,736.40	38.52	1,879.53	8,613.63	33,017.65	258,076.12
Quarterly L2B repo volumes (PRA110) (£million)	220	31,373.65	72,351.38	14.90	334.69	2,849.22	24,988.02	195,674.90
Quarterly other repo volumes (PRA110) (£million)	179	143,254.32	208,998.06	197.88	13,707.92	54,521.20	198,509.22	581,129.67
Quarterly L1 (gilt) reverse repo volumes (PRA110) (£million)	116	196,391.16	171,269.34	1,766.80	50,678.24	165,300.66	297,106.70	412,426.62
Quarterly L2A reverse repo volumes (PRA110) (£million)	174	68,582.80	96,485.41	80.50	5,227.42	31,047.55	81,863.95	297,133.37
Quarterly L2B reverse repo volumes (PRA110) (£million)	231	65,481.01	141,140.43	39.94	671.11	7,699.61	67,279.06	304,836.49
Quarterly Other reverse repo volumes (PRA110) (£million)	180	148,417.60	199,753.32	261.08	14,225.17	68,276.92	213,801.97	476,173.75
Quarterly L1 (gilt) collateral swap inflows volumes (PRA110) (£million)	61	1,049.12	2,156.03	2.37	15.01	65.05	982.59	4,329.63
Quarterly L2A collateral swap inflows volumes (PRA110) (£million)	143	9,891.60	25,120.58	2.91	63.48	534.70	6,856.41	46,020.12
Quarterly L2B collateral swap inflows volumes (PRA110) (£million)	154	17,257.65	25,305.08	22.57	782.72	6,257.89	25,970.06	57,826.29
Quarterly other collateral swap inflows volumes (PRA110) (£million)	158	29,052.43	39,067.61	108.95	1,973.09	11,650.20	39,474.40	124,806.17
Quarterly L1 (gilt) collateral swap outflows volumes (PRA110) (£million)	55	1,868.61	2,007.84	46.34	212.13	949.36	2,765.85	5,643.00
Quarterly L2A collateral swap outflows volumes (PRA110) (£million)	142	46,586.96	52,658.17	24.05	4,460.41	25,350.39	77,863.52	153,886.17
Quarterly L2B collateral swap outflows volumes (PRA110) (£million)	148	45,197.87	76,818.96	104.15	3,515.94	11,903.98	38,354.38	214,863.47
Quarterly other collateral swap outflows volumes (PRA110) (£million)	166	58,229.11	87,192.30	526.33	5,200.92	16,116.37	71,010.42	198,724.75
Panel C: Prices								
Daily gilt general repo mean excess rates (SMMD) (%)	19,179	−0.037	0.075	−0.130	−0.070	−0.032	−0.003	0.050
Daily gilt general reverse repo mean excess rates (SMMD) (%)	11,482	−0.001	0.085	−0.105	−0.032	0.000	0.037	0.100
Quarterly gilt general repo mean excess rates (SMMD) (%)	769	−0.016	0.059	−0.100	−0.054	−0.015	0.020	0.074
Quarterly gilt general reverse repo mean excess rates (SMMD) (%)	689	0.010	0.068	−0.077	−0.026	0.008	0.041	0.114
Daily gilt special repo mean excess rates (SMMD) (%)	39,443	−0.066	0.086	−0.178	−0.098	−0.060	−0.023	0.020
Daily gilt special reverse repo mean excess rates (SMMD) (%)	45,890	0.012	0.131	−0.135	−0.065	−0.017	0.073	0.260
Quarterly gilt special repo mean excess rates (SMMD) (%)	1,383	−0.062	0.088	−0.154	−0.096	−0.057	−0.023	0.020
Quarterly gilt special reverse repo mean excess rates (SMMD) (%)	1,410	0.008	0.127	−0.136	−0.075	−0.019	0.094	0.213

C Microstructure evolution results

Table C1: Repo borrowing and reverse repo lending volumes backed by gilts evolution. This table reports estimates from OLS regressions of daily gilt repo transaction volumes in columns (1)-(3), and daily gilt reverse repo transaction volumes in columns (4)-(6) on dummy variables capturing different years and counterparty sectors using the SMMD dataset. Standard errors are robust to heteroskedasticity. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020.

Dependent Variable:	Log(Volume) (t)					
	(1) (HF repo)	(2) (IF repo)	(3) (All MBF repo)	(4) (HF reverse repo)	(5) (IF reverse repo)	(6) (All MBF reverse repo)
Dealer 2016 ST	18.552***	18.552***	18.552***	18.714***	18.714***	18.714***
	(195.557)	(195.691)	(195.787)	(194.010)	(194.142)	(194.284)
Dealer 2016 LT	19.665***	19.665***	19.665***	18.708***	18.708***	18.708***
	(95.142)	(95.207)	(95.254)	(71.721)	(71.770)	(71.823)
Dealer 2017 ST	0.150	0.150	0.150	−0.201	−0.201	−0.201
	(1.110)	(1.111)	(1.112)	(−1.540)	(−1.541)	(−1.542)
Dealer 2017 LT	−0.866***	−0.866***	−0.866***	−0.117	−0.117	−0.117
	(−2.718)	(−2.719)	(−2.721)	(−0.339)	(−0.339)	(−0.340)
Dealer 2018 ST	0.971***	0.971***	0.971***	0.810***	0.810***	0.810***
	(8.190)	(8.195)	(8.199)	(6.354)	(6.359)	(6.363)
Dealer 2018 LT	−0.868***	−0.868***	−0.868***	0.180	0.180	0.180
	(−3.693)	(−3.696)	(−3.697)	(0.621)	(0.621)	(0.622)
Dealer 2019 ST	0.653***	0.653***	0.653***	0.486***	0.486***	0.486***
	(4.783)	(4.786)	(4.789)	(3.547)	(3.550)	(3.552)
Dealer 2019 LT	−0.448*	−0.448*	−0.448*	0.564**	0.564**	0.564**
	(−1.896)	(−1.898)	(−1.898)	(1.994)	(1.996)	(1.997)
Dealer 2020 ST	1.072***	1.072***	1.072***	0.808***	0.808***	0.808***
	(7.933)	(7.939)	(7.943)	(5.980)	(5.984)	(5.988)
Dealer 2020 LT	−0.677**	−0.677**	−0.677**	0.243	0.243	0.243
	(−2.333)	(−2.335)	(−2.336)	(0.758)	(0.758)	(0.759)
MBF 2016 ST	19.033***	20.469***	20.138***	18.742***	18.459***	18.172***
	(228.838)	(247.891)	(237.675)	(225.829)	(262.551)	(296.296)
MBF 2016 LT	17.735***	17.894***	17.714***	17.273***	17.545***	17.959***
	(110.689)	(146.656)	(152.811)	(104.574)	(171.678)	(271.079)
MBF 2017 ST	1.901***	1.128***	0.295**	2.110***	1.032***	0.846***
	(20.462)	(12.471)	(2.513)	(22.611)	(9.003)	(9.113)
MBF 2017 LT	0.000	−0.272*	−0.128	0.411**	0.226*	0.107
	(0.002)	(−1.704)	(−0.893)	(2.067)	(1.783)	(1.234)
MBF 2018 ST	2.291***	1.425***	0.251**	2.408***	0.805***	0.802***
	(24.550)	(15.855)	(2.147)	(26.268)	(6.506)	(8.642)
MBF 2018 LT	0.455**	0.308*	0.188	0.674***	0.272**	0.427***
	(2.277)	(1.850)	(1.280)	(3.360)	(2.063)	(4.812)
MBF 2019 ST	2.565***	1.784***	0.413***	2.829***	1.763***	1.200***
	(28.757)	(19.999)	(3.543)	(32.059)	(14.520)	(12.421)
MBF 2019 LT	0.346*	0.308*	0.298*	0.460**	0.129	0.341***
	(1.660)	(1.763)	(1.960)	(2.233)	(0.940)	(3.700)
MBF 2020 ST	2.327***	1.821***	0.165	2.612***	2.432***	1.744***
	(25.847)	(19.211)	(1.439)	(28.888)	(22.696)	(21.578)
MBF 2020 LT	−0.071	−0.050	−0.092	0.017	−0.143	0.359***
	(−0.316)	(−0.274)	(−0.632)	(0.073)	(−0.958)	(3.591)
CCP 2016 ST	22.149***	22.149***	22.149***	22.446***	22.446***	22.446***
	(365.638)	(365.889)	(366.068)	(605.283)	(605.696)	(606.138)
CCP 2016 LT	19.374***	19.374***	19.374***	18.797***	18.797***	18.797***
	(199.689)	(199.826)	(199.924)	(173.476)	(173.594)	(173.721)
CCP 2017 ST	1.029***	1.029***	1.029***	0.700***	0.700***	0.700***
	(16.353)	(16.364)	(16.372)	(17.370)	(17.382)	(17.395)
CCP 2017 LT	0.257**	0.257**	0.257**	0.584***	0.584***	0.584***
	(2.201)	(2.203)	(2.204)	(4.546)	(4.549)	(4.553)
CCP 2018 ST	1.528***	1.528***	1.528***	0.859***	0.859***	0.859***
	(24.304)	(24.321)	(24.333)	(21.176)	(21.190)	(21.206)
CCP 2018 LT	0.096	0.096	0.096	0.162	0.162	0.162
	(0.769)	(0.769)	(0.770)	(1.168)	(1.169)	(1.170)
CCP 2019 ST	1.468***	1.468***	1.468***	0.881***	0.881***	0.881***
	(23.328)	(23.344)	(23.355)	(21.990)	(22.005)	(22.021)
CCP 2019 LT	−0.056	−0.056	−0.056	0.185	0.185	0.185
	(−0.486)	(−0.486)	(−0.487)	(1.437)	(1.438)	(1.439)
CCP 2020 ST	1.359***	1.359***	1.359***	0.787***	0.787***	0.787***
	(21.797)	(21.812)	(21.822)	(18.942)	(18.955)	(18.969)
CCP 2020 LT	0.138	0.138	0.138	0.560***	0.560***	0.560***
	(1.143)	(1.144)	(1.144)	(4.236)	(4.239)	(4.242)
Observations	4,877	6,268	7,866	4,830	6,179	8,821
R^2	0.998	0.997	0.993	0.998	0.995	0.995

Table C2: Repo borrowing volumes backed by gilts evolution. This table reports estimates from OLS regressions of daily gilt repo transaction volumes on dummy variables capturing different years and counterparty sectors using the SMMD dataset. Standard errors are robust to heteroskedasticity. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020.

Dependent Variable:	Log(Volume) (t)	
	(1) (HF repo)	(2) (HF repo)
Dealer 2016 ST	18.552***	18.062***
	(195.517)	(243.909)
Dealer 2016 LT	19.665***	19.583***
	(95.122)	(94.925)
Dealer 2017 ST	0.150	−0.115
	(1.110)	(−1.034)
Dealer 2017 LT	−0.866***	−0.893***
	(−2.717)	(−2.959)
Dealer 2018 ST	0.971***	0.241**
	(8.188)	(2.456)
Dealer 2018 LT	−0.868***	−0.897***
	(−3.692)	(−3.622)
Dealer 2019 ST	0.653***	0.205*
	(4.782)	(1.915)
Dealer 2019 LT	−0.448*	−0.566**
	(−1.896)	(−2.469)
Dealer 2020 ST	1.072***	0.386***
	(7.932)	(3.652)
Dealer 2020 LT	−0.677**	−0.633**
	(−2.333)	(−2.253)
MBF 2016 ST	19.033***	18.943***
	(228.791)	(234.108)
MBF 2016 LT	17.735***	17.688***
	(110.666)	(114.384)
MBF 2017 ST	1.901***	1.263***
	(20.457)	(10.368)
MBF 2017 LT	0.000	−0.013
	(0.002)	(−0.071)
MBF 2018 ST	2.291***	1.423***
	(24.545)	(12.134)
MBF 2018 LT	0.455**	0.463**
	(2.276)	(2.487)
MBF 2019 ST	2.565***	1.468***
	(28.751)	(13.195)
MBF 2019 LT	0.346*	0.177
	(1.659)	(0.875)
MBF 2020 ST	2.218***	0.488***
	(24.616)	(4.913)
MBF 2020 LT	0.066	−0.308
	(0.296)	(−1.463)
MBF 2020 ST Covid	0.607***	
	(7.885)	
MBF 2020 LT Covid	−1.072*	
	(−1.783)	
MBF 2020 ST Covid B1		1.642***
		(7.977)
MBF 2020 LT Covid B1		−0.759
		(−1.180)
MBF 2020 ST Covid B2		−0.617***
		(−4.089)
MBF 2020 LT Covid B2		−1.405***
		(−9.796)
CCP 2016 ST	22.149***	20.153***
	(365.563)	(483.699)
CCP 2016 LT	19.374***	19.106***
	(199.648)	(229.715)
CCP 2017 ST	1.029***	0.425***
	(16.350)	(8.343)
CCP 2017 LT	0.257**	0.106
	(2.201)	(1.085)
CCP 2018 ST	1.528***	0.438***
	(24.299)	(8.612)
CCP 2018 LT	0.096	−0.020
	(0.769)	(−0.203)
CCP 2019 ST	1.468***	0.084*
	(23.323)	(1.662)
CCP 2019 LT	−0.056	−0.178*
	(−0.486)	(−1.893)
CCP 2020 ST	1.359***	0.011
	(21.792)	(0.207)
CCP 2020 LT	0.138	−0.156*
	(1.142)	(−1.652)
Observations	4,877	17,589
R^2	0.998	0.995

D Regional results

Table D1: Repo borrowing volumes and regulatory ratios by region. This table reports estimates from OLS regressions of regional quarterly gilt general collateral and special collateral repo transaction volumes in columns (1)-(2), and quarterly repo holdings volumes in columns (3)-(4) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020 for columns (1)-(2), January 2020 to November 2020 for column (3) and July 2019 to November 2020 for column (4).

Dependent Variable:	Log(Volume) (t)			
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A, L2B, Other)
LCR (%) ($t-1$) * ST	0.015***	0.017***	0.003	0.008*
	(3.799)	(5.757)	(2.253)	(2.172)
LCR (%) ($t-1$) * LT	−0.010**	−0.010**	−0.006	0.005
	(−2.206)	(−2.859)	(−2.914)	(1.133)
CR (%) ($t-1$)	0.102	−0.036	−0.002	−0.405*
	(1.527)	(−0.754)	(−0.031)	(−2.775)
CR Asia (%) ($t-1$)				0.309**
				(2.848)
CR EU (%) ($t-1$)				0.090
				(1.186)
CR US (%) ($t-1$)				0.059
				(0.440)
LR (%) ($t-1$)	−1.069*	0.413	−0.460	0.395
	(−1.751)	(0.892)	(−0.996)	(1.034)
LR Asia (%) ($t-1$)	0.890	−0.059	0.427	
	(1.259)	(−0.145)	(0.878)	
LR EU (%) ($t-1$)	0.716	−0.632	0.437	
	(1.269)	(−1.396)	(0.967)	
LR US (%) ($t-1$)	1.567**	−0.115	0.454	
	(2.726)	(−0.183)	(0.964)	
Intercept	21.974***	22.048***	26.498***	25.716***
	(13.556)	(18.889)	(18.996)	(14.517)
Quarter fixed effects	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	532	870	115	560
R^2	0.769	0.797	0.872	0.450

Table D2: Reverse repo lending volumes and regulatory ratios by region. This table reports estimates from OLS regressions of regional quarterly gilt general collateral and special collateral reverse repo transaction volumes in columns (1)-(2), and quarterly reverse repo holdings volumes in columns (3)-(4) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020 for columns (1)-(2), January 2020 to November 2020 for column (3) and July 2019 to November 2020 for column (4).

Dependent Variable:	Log(Volume) (t)			
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A, L2B, Other)
LCR (%) ($t-1$) * ST	0.002	0.017*	−0.010	−0.032*
	(0.205)	(1.770)	(−0.909)	(−2.600)
LCR (%) ($t-1$) * LT	−0.017*	−0.002	−0.009	−0.028*
	(−1.737)	(−0.147)	(−0.856)	(−2.596)
LCR Asia (%) ($t-1$) * ST	0.028**	−0.012	0.004	0.034*
	(2.583)	(−1.239)	(0.306)	(2.776)
LCR Asia (%) ($t-1$) * LT	0.030**	−0.014	−0.002	0.026*
	(2.698)	(−1.193)	(−0.193)	(2.550)
LCR EU (%) ($t-1$) * ST	−0.004	−0.005	0.017	0.020
	(−0.320)	(−0.482)	(1.234)	(1.534)
LCR EU (%) ($t-1$) * LT	0.009	−0.009	0.003	0.019
	(0.808)	(−0.732)	(0.293)	(1.735)
LCR US (%) ($t-1$) * ST	0.003	−0.005	0.015	0.040**
	(0.329)	(−0.463)	(1.932)	(2.883)
LCR US (%) ($t-1$) * LT	0.008	−0.002	0.014	0.033*
	(0.868)	(−0.197)	(1.935)	(2.717)
CR (%) ($t-1$)	−0.099	0.051	−0.158	−0.090
	(−0.860)	(0.808)	(−1.828)	(−0.951)
LR (%) ($t-1$)	−0.060	−0.157*	0.247	0.092
	(−0.461)	(−1.888)	(1.365)	(0.184)
Intercept	23.651***	22.700***	27.618***	26.583***
	(14.318)	(26.446)	(32.412)	(16.750)
Quarter fixed effects	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	457	895	116	583
R^2	0.584	0.796	0.907	0.625

E Collateral shock results

Table E1: Gilt repo and reverse repo volumes and regulatory ratios by collateral shock. This table reports estimates from OLS regressions of quarterly gilt special collateral repo and reverse repo transaction volumes of different collateral price volatility on the regulatory ratios using the SMMD dataset. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from 15th August 2019 to 15th October 2019 for columns (1)-(2) and from 28th February 2020 to 30th April 2020 for columns (3)-(4).

Dependent Variable:	Log(Volume) (t)	
	(1) (SC Repo)	(2) (SC Reverse repo)
CR (%) ($t-1$)	−0.000	0.069
	(−0.003)	(1.169)
LR (%) ($t-1$) * B1 * Shock	−1.193***	−0.364**
	(−5.813)	(−2.251)
LR (%) ($t-1$) * B2 * Shock	−0.807***	−0.260**
	(−4.347)	(−2.137)
LR (%) ($t-1$) * B1 * No shock	−0.215	−0.232*
	(−1.649)	(−1.992)
LR (%) ($t-1$) * B2 * No shock	−0.160	−0.210***
	(−1.325)	(−2.908)
LCR (%) ($t-1$) * ST * B1 * Shock	0.029***	0.003
	(3.043)	(0.435)
LCR (%) ($t-1$) * ST * B2 * Shock	0.042***	0.012**
	(4.484)	(2.264)
LCR (%) ($t-1$) * LT * B1 * Shock	0.006	−0.009
	(0.661)	(−1.504)
LCR (%) ($t-1$) * LT * B2 * Shock	0.004	−0.007
	(0.581)	(−1.332)
LCR (%) ($t-1$) * ST * B1 * No shock	0.015***	0.013***
	(6.035)	(7.589)
LCR (%) ($t-1$) * ST * B2 * No shock	0.015***	0.013***
	(4.222)	(6.657)
LCR (%) ($t-1$) * LT * B1 * No shock	−0.012***	−0.006***
	(−4.651)	(−3.381)
LCR (%) ($t-1$) * LT * B2 * No shock	−0.011**	−0.005**
	(−2.390)	(−2.208)
Intercept	23.760***	22.761***
	(23.938)	(30.670)
Quarter fixed effects	Yes	Yes
Bank fixed effects	Yes	Yes
Observations	870	895
R^2	0.822	0.800

F Alternative volumes aggregation results

Table F1: Repo borrowing volumes and regulatory ratios. This table reports estimates from OLS regressions of quarter first-day gilt general collateral and special collateral repo transaction volumes in columns (1)-(2), and quarter first-day repo holdings volumes in columns (3)-(6) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020 for columns (1)-(2), January 2020 to November 2020 for column (3) and July 2019 to November 2020 for columns (4)-(6).

Dependent Variable:	Log(Volume) (t)					
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A)	(5) (PRA110 L2B)	(6) (PRA110 Other)
LCR (%) ($t-1$) * ST	0.012***	0.007***	0.003	0.009*	0.013**	0.001
	(2.966)	(2.999)	(1.386)	(2.590)	(3.093)	(0.801)
LCR (%) ($t-1$) * LT	0.002	−0.014***	−0.006	−0.005	0.014**	0.003
	(0.383)	(−4.248)	(−2.282)	(−0.907)	(4.037)	(1.595)
CR (%) ($t-1$)	0.226**	−0.003	−0.038	−0.114	−0.438**	0.008
	(2.500)	(−0.076)	(−0.516)	(−0.958)	(−3.095)	(0.118)
LR (%) ($t-1$)	−0.239**	−0.111	0.120	−0.698	0.882	0.182
	(−2.722)	(−0.997)	(0.701)	(−1.479)	(1.031)	(0.882)
Intercept	15.743***	20.514***	22.820***	25.042***	19.967***	20.412***
	(13.372)	(17.729)	(15.422)	(9.533)	(4.755)	(12.467)
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	373	571	110	148	144	165
R^2	0.596	0.691	0.873	0.849	0.613	0.851

Table F2: Reverse repo lending volumes and regulatory ratios. This table reports estimates from OLS regressions of quarter first-day gilt general collateral and special collateral reverse repo transaction volumes in columns (1)-(2), and quarter first-day reverse repo holdings volumes in columns (3)-(6) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020 for columns (1)-(2), January 2020 to November 2020 for column (3) and July 2019 to November 2020 for columns (4)-(6).

Dependent Variable:	Log(Volume) (t)					
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A)	(5) (PRA110 L2B)	(6) (PRA110 Other)
LCR (%) ($t-1$) * ST	−0.001	0.011***	0.006	−0.009*	−0.002	−0.003
	(−0.201)	(3.956)	(1.628)	(−2.748)	(−0.355)	(−0.729)
LCR (%) ($t-1$) * LT	−0.002	−0.008**	0.004	−0.012**	−0.000	−0.004
	(−0.715)	(−2.846)	(1.573)	(−3.293)	(−0.074)	(−1.416)
CR (%) ($t-1$)	0.114	0.054	−0.152	0.134	0.301	0.251
	(1.522)	(0.612)	(−2.386)	(0.741)	(1.453)	(1.997)
LR (%) ($t-1$)	−0.249**	−0.214	0.311*	−0.720	−0.623	−0.167
	(−2.865)	(−1.484)	(3.991)	(−1.565)	(−1.109)	(−0.486)
Intercept	18.544***	19.240***	23.057***	24.253***	18.238**	18.986***
	(16.238)	(14.668)	(29.401)	(6.940)	(3.361)	(44.971)
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	346	673	111	161	165	163
R^2	0.297	0.664	0.842	0.827	0.755	0.666

Table F3: Repo borrowing volumes and regulatory ratios. This table reports estimates from OLS regressions of quarter last-day gilt general collateral and special collateral repo transaction volumes in columns (1)-(2), and quarter last-day repo holdings volumes in columns (3)-(6) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020 for columns (1)-(2), January 2020 to November 2020 for column (3) and July 2019 to November 2020 for columns (4)-(6).

Dependent Variable:	Log(Volume) (t)					
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A)	(5) (PRA110 L2B)	(6) (PRA110 Other)
LCR (%) ($t-1$) * ST	0.009*	0.009***	0.005	0.013**	0.007	−0.001
	(2.013)	(3.036)	(2.496)	(3.230)	(2.128)	(−0.452)
LCR (%) ($t-1$) * LT	0.005	−0.011***	−0.003	0.000	0.007	0.001
	(1.013)	(−3.222)	(−1.325)	(0.097)	(1.769)	(0.536)
CR (%) ($t-1$)	0.103	−0.041	0.062	−0.242	−0.302	−0.094*
	(0.952)	(−1.022)	(0.414)	(−1.706)	(−1.696)	(−2.232)
LR (%) ($t-1$)	−0.360***	−0.013	−0.003	0.493	0.461*	0.083
	(−3.096)	(−0.128)	(−0.013)	(1.347)	(2.234)	(0.698)
Intercept	18.538***	19.897***	21.388***	20.515***	21.798***	23.092***
	(10.619)	(22.928)	(11.507)	(11.323)	(9.017)	(283.984)
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	360	533	109	146	144	164
R^2	0.537	0.649	0.891	0.873	0.797	0.835

Table F4: Reverse repo lending volumes and regulatory ratios. This table reports estimates from OLS regressions of quarter last-day gilt general collateral and special collateral reverse repo transaction volumes in columns (1)-(2), and quarter last-day reverse repo holdings volumes in columns (3)-(6) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020 for columns (1)-(2), January 2020 to November 2020 for column (3) and July 2019 to November 2020 for columns (4)-(6).

Dependent Variable:	Log(Volume) (t)					
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A)	(5) (PRA110 L2B)	(6) (PRA110 Other)
LCR (%) ($t-1$) * ST	0.005***	0.009***	0.001	0.011	0.000	−0.002
	(3.949)	(3.039)	(0.342)	(1.620)	(0.024)	(−0.566)
LCR (%) ($t-1$) * LT	0.005***	−0.010***	0.000	0.009	0.000	−0.004
	(4.336)	(−3.107)	(0.018)	(1.535)	(0.040)	(−0.715)
CR (%) ($t-1$)	−0.000	−0.018	−0.093	−0.304**	0.322	0.178
	(−0.003)	(−1.177)	(−0.423)	(−2.865)	(1.542)	(1.403)
LR (%) ($t-1$)	−0.130	−0.050	−0.139	1.263**	0.554**	−0.541
	(−1.201)	(−0.666)	(−0.326)	(2.818)	(3.553)	(−0.591)
Intercept	18.734***	19.527***	25.113***	18.230***	12.484*	22.069***
	(14.969)	(58.271)	(10.116)	(12.763)	(2.695)	(6.239)
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	346	621	109	159	165	166
R^2	0.325	0.642	0.854	0.831	0.887	0.653

Table F5: Repo borrowing volumes and regulatory ratios. This table reports estimates from OLS regressions of quarter-average gilt general collateral and special collateral repo transaction volumes in columns (1)-(2), and quarter-average repo holdings volumes in columns (3)-(6) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.The sample covers the period from February 2016 to November 2020 for columns (1)-(2), January 2020 to November 2020 for column (3) and July 2019 to November 2020 for columns (4)-(6).

Dependent Variable:	Log(Volume) (t)					
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A)	(5) (PRA110 L2B)	(6) (PRA110 Other)
LCR (%) ($t-1$) * ST	0.001	0.001	0.003	0.010*	0.006*	0.000
	(0.539)	(0.998)	(2.292)	(2.142)	(2.245)	(0.121)
LCR (%) ($t-1$) * LT	0.001	0.002*	−0.003	−0.000	0.006	0.003
	(1.395)	(1.809)	(−1.927)	(−0.016)	(1.771)	(1.195)
CR (%) ($t-1$)	0.021	0.002	0.024	−0.116*	−0.248	−0.060
	(0.751)	(0.064)	(0.313)	(−2.195)	(−2.108)	(−1.169)
LR (%) ($t-1$)	−0.089***	−0.073**	0.033	0.039	0.443	−0.114
	(−4.057)	(−2.676)	(0.214)	(0.264)	(1.021)	(−1.219)
Intercept	18.676***	17.664***	20.053***	19.728***	19.003***	21.342***
	(49.262)	(36.522)	(16.750)	(14.095)	(16.533)	(13.494)
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	532	870	115	161	220	178
R^2	0.389	0.332	0.810	0.877	0.421	0.725

Table F6: Reverse repo lending volumes and regulatory ratios. This table reports estimates from OLS regressions of quarter-average gilt general collateral and special collateral reverse repo transaction volumes in columns (1)-(2), and quarter-average reverse repo holdings volumes in columns (3)-(6) on the regulatory ratios using the SMMD and PRA110 datasets. Standard errors are double-clustered at the quarter and bank levels. t-statistics are presented in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. The sample covers the period from February 2016 to November 2020 for columns (1)-(2), January 2020 to November 2020 for column (3) and July 2019 to November 2020 for columns (4)-(6).

Dependent Variable:	Log(Volume) (t)					
	(1) (SMMD GC)	(2) (SMMD SC)	(3) (PRA110 L1)	(4) (PRA110 L2A)	(5) (PRA110 L2B)	(6) (PRA110 Other)
LCR (%) ($t-1$) * ST	0.002*	0.001	0.002	−0.001	−0.004	−0.002
	(1.829)	(1.095)	(0.787)	(−0.195)	(−1.484)	(−1.144)
LCR (%) ($t-1$) * LT	0.004***	0.002*	0.000	−0.002	−0.003*	−0.003
	(3.760)	(1.926)	(0.120)	(−0.847)	(−2.213)	(−1.783)
CR (%) ($t-1$)	−0.037	0.001	−0.041	−0.069	−0.047	0.057
	(−0.925)	(0.045)	(−0.530)	(−0.596)	(−0.629)	(1.202)
LR (%) ($t-1$)	−0.045	−0.040	0.138	0.369	0.571	0.031
	(−1.510)	(−1.310)	(1.088)	(0.817)	(0.957)	(0.153)
Intercept	18.890***	17.338***	20.688***	19.022***	16.874***	19.070***
	(31.708)	(43.057)	(35.218)	(8.243)	(7.355)	(30.576)
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	457	895	116	174	230	180
R^2	0.506	0.458	0.783	0.765	0.614	0.820