Bank of England

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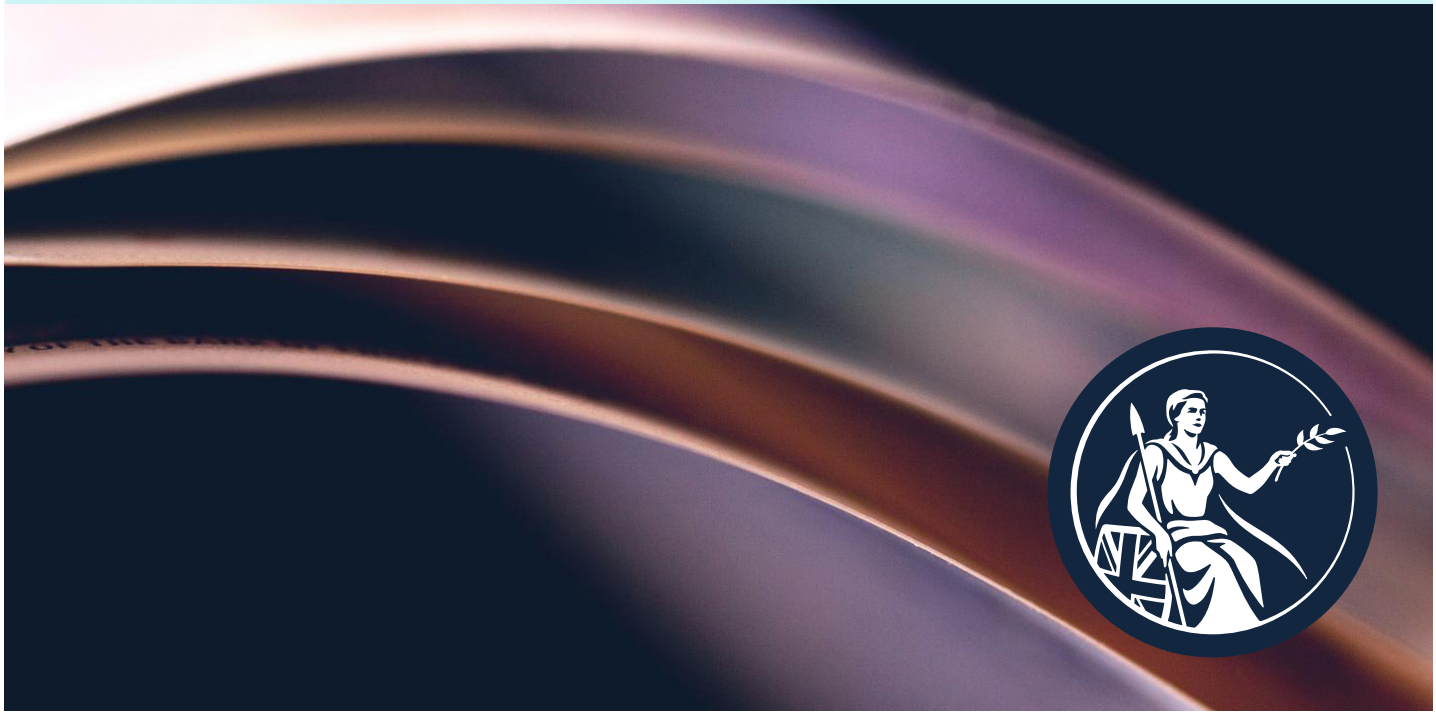

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Irem Erten,[1] Ioana Neamțu[2] and John Thanassoulis[3]

Abstract

We study the impact of ring-fencing on risk-taking in the financial sector using short-term money markets. Ring-fencing is when the government restricts some activities to a subsidiary of the group whilst restricting intra-group transfers. Exploiting confidential data on sterling-denominated repo transactions, we document that banking groups subject to ring-fencing are perceived to be safer; repo investors lend to ring-fenced groups at lower rates. We show that ring-fenced groups reduce their risk-appetite and that the safety perception is amplified during times of market stress. Our paper suggests that structural reforms can create a 'safe haven' bank in the financial system.

Key words: Ring-fencing, repo markets, risk-taking.

JEL classification: G12, G18, G21.

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1 Introduction

What happens to risk in the banking system when the government breaks banking groups into separate subsidiaries? Ring fencing occurs when the government restricts some banking activities, and some risks, to a subsidiary of the banking group which cannot freely exchange capital with the rest of the group (Schwarcz (2013)). The UK is one of the few countries that implemented ring-fencing in the aftermath of the Great Financial Crisis of 2008, though the EU considered it.[1] We empirically study the impact of this structural separation on bank's risk-taking and how their riskiness is perceived by their peers using interest rates in the UK repo market as an insight into market participants' views.

Some vulnerabilities remain in the banking system even after the Great Financial Crisis. In March 2023 the rapid collapse of SVB and Signature banks led to contagion across American banks as market participants shunned other banks they deemed to be unsafe.[2] To maintain liquidity the U.S. authorities decided the preferred course of action was to increase the federal deposit guarantee to cover *all* bank deposits. We document flight-to-safety results by market participants towards ring-fenced banks during stress times, established both via repo trades and balance sheet measures. This paper thus suggests that such a retail-investment banking insulation reform can provide immunity to a deposit run such as the one experienced in the SVB crisis episode, and can be a private-sector solution to the creation of banks which can be trusted as safe holders of cash even in stress times.

The effects of structural reforms, such as ring-fencing, on bank risk are far from being understood. The question of whether ring-fencing improves financial stability remains open. To the

[1] See Vickers (2011) for the details on the Independent Commission on Banking in the UK which recommended the ring-fence approach. The EU had a similar report, the Liikanen report (Liikanen, 2012), which also recommended a form of ring-fencing. This was not however finally implemented within the EU.

[2] These included First Republic bank, PacWest Bancorp, Regions Financial, and Zions Bancorporation. For details see The Silicon Valley Bank collapse: What you need to know, *Bankrate*, March 27 2023.

best of our knowledge this paper is the first to study how bank risk is affected by ring-fencing using the short-term money markets. The repo market in the UK consists of predominantly bilateral negotiated transactions between dealer banks and financial institutions. The repo prices therefore represent real-time assessments of lender and borrower risk made by sophisticated market participants. The UK repo market is an ideal laboratory to use to study parties' views on each others' credit risk as the high degree of safety allows us to separate out the credit risk we seek to measure from collateral and duration risk which strongly affect other lending markets, improving our identification. And even though the collateral is very safe, repo lenders remain concerned by credit risk due to, for example: costs incurred if ever collateral had to be seized or managed; or regulatory attention to balance sheet. For these reasons we have chosen to use the UK repo market to explore banks' risk perceptions of each other and risk-taking. We run a sequence of statistical tests, described shortly, which establish how third parties perceive the riskiness of banking groups obliged to ring-fence. The richness of the environment allows us to establish that the ring-fencing bonus we identify is robust even, and especially, in stress times.

The structural separation implemented in the UK is novel. The ring-fencing legislation was enacted to ensure that deposit taking institutions would maintain a number of critical financial services protected from risks to the wider bank. The legislation was also designed to ensure that ring-fenced banks were easier to supervise, and if necessary, resolve. The initial report which proposed ring-fencing described it as follows:

> "The objective of such a ring-fence would be to isolate those banking activities where continuous provision of service is **vital** to the economy and to a bank's customers. This would be in order to ensure, first, that such provision **could not be threatened** ..."
> Vickers (2011), p11, emphasis added.

Taken at face value this suggests that regulation, and if necessary a government guarantee,

should ensure that a ring-fenced bank (RFB) was, and should be seen to be, less risky. Whether this means that the other subsidiaries in the group (nRFB) are more risky – e.g. if the nRFB loses any perceived government guarantee, or sees reduced supervision – or not is an open question. Hence at the group level ring-fencing may be damaging, or not. Further, if the intervention were effective then it might make the ring-fenced banking subsidiary a safe bank to which others gravitate in stress times: *a safe haven* to lend cash to.

There are at least two reasons to hypothesise that ring-fencing creates a bonus to the affected group and can generate a bank perceived as safe in stress times. Firstly banking groups can have very complex structures which potentially inhibit effective and timely supervision. Breaking such complex groups up into separate subsidiaries may reduce this complexity and so facilitate supervision, thus lowering risk. Secondly, splitting the group into distinct legal entities offers a regulator options in times of stress. For example a regulator could credibly step in to support just part of a banking group, thus perhaps reducing moral hazard and therefore risk. Whether these different positive effects occur on the RFB subsidiary and possibly the nRFB too, has not been studied.

There is a negative set of possible implications of ring-fencing however. Firstly the ring-fence by design prevents the free transfer of trades across the banking group. Therefore the ability of a bank to net-off trades will be reduced, potentially causing diversification benefits to be lost (Kashyap et al. (2002)). Secondly some have argued that under the ring-fencing framework, banks may simply become inclined to take greater risks inside the fence as the too-vital-to-fail (TVTF) designation encourages moral hazard (Acharya et al. (2022)). Finally RFBs may respond to the ring-fence by over-weighting their assets on the domestic economy. In the case of the UK (as opposed to the US) this corresponds to a comparatively concentrated market.[3] For all these reasons it is possible that

[3]See Fed St Louis data on 5-Bank Asset Concentration for UK and US.

the wider market will perceive a ring-fenced banking group as more, not less, risky.

To study risk-taking and the perceived riskiness of banks we use a confidential and unique database of sterling-denominated repo transactions. Our data allows us to observe, on a granular and high-frequency basis, the near-universe of sterling-denominated repo transactions collateralised by UK gilt collateral. Government bond collateralised repo transactions are an ideal setting to isolate the effects of counterparty risk, as it is the largest identified risk in these markets, and there is evidence that it was transmitted through repo rates especially during crises (Gorton and Metrick, 2012).[4] Controlling for duration risk (via maturity information) and credit risk (via collateral), the dataset allows us to measure the effect of the reform on perceived risk and risk attitude. The repo market is one of the core liquidity sources for banks in the UK, and a major source of overnight cash investment for a large variety of financial intermediaries. The UK stands as the fourth largest repo market in the world with a notional size of repo and reverse repo transactions worth USD $900 billion (BIS CGFS (2017)), and the total gross UK settlement over two days equals UK GDP (Ball et al. (2011)). Importantly we are able to obtain the counterparty identities and time stamps needed for identification. The observed daily prices for repos and reverse-repos permit a real-time assessment of the risks financial institutions perceive in all the banks they interact with. We exploit the stylized fact that counterparties trade with several dealers within very short time periods. This allows us to systematically account for any time-varying confounders, and compare for the same counterparty, the risk perception and price of liquidity across similar dealers in very similar transactions within these very short time periods.

Our empirical identification also leverages the fact that the regulatory intervention only requires the UK banking groups with more than £25 billion of "core" deposits (see §2 below) to have a ring-fenced subsidiary. Thus, our set-up allows us to naturally split the dealer banks into treated and

[4]Despite being considered by industry bodies as the most important risk in repo transactions (ICMA, 2024), and proposed in theoretical settings as an explanation for the 2007 liquidity crisis in the US (Ewerhart and Tapking, 2008), there are few empirical studies that can directly measure the (perceived) counterparty risk due to data availability.

control groups, that we find to be broadly similar. The £25 billion of deposits threshold is imposed on a three-year-rolling window, which makes it further unlikely to be manipulated by the individual bank dealers. Furthermore, our bank dealers are very large multinational banks with a large variety of global funding sources, and thus, we believe that the threshold imposed on the UK deposits is largely exogenous to the consolidated banking group as a whole. We also replicate our empirical analysis by matching our treatment group based on a rich set of pre-treatment bank characteristics using the nearest-neighbour propensity-score matching method.

In the first part of the paper, we investigate the risk perception third parties have of RFB groups as evidenced by the interest rate which RFB groups have to pay to borrow cash from third parties in the repo markets. We compare the repo lending by the same counterparty to the ring-fenced dealers relative to other dealers in a diff-in-diff empirical specification. We control for the loan and collateral characteristics during the study period. We also capture the banks' business model by controlling for the bank identities. And most powerfully we use counterparty-by-day fixed effects so that we are in effect looking at differences manifesting across all clients with the same dealer on the same day.

We document that the ring-fenced dealers can borrow in the overnight repo market at 0.885 bps lower rates (approx 3.54% less relative to the median repo rate) as compared to other dealer banks exempt from ring-fencing. This is a ring-fencing bonus for banking groups containing an RFB subsidiary, and it is statistically significant at the 1% level. This is evidence that counterparties (the repo investors) perceive the dealers containing a ring-fenced subsidiary to be safer after the reform. This ring-fencing bonus can be clearly identified because the UK repo market allows us to isolate the effect of credit risk from duration and collateral risk in bilateral repo negotiations. The lower riskiness perceived by counterparties of the dealer banking groups containing an RFB could have at least two causes: the first is that the group is indeed safer due to a combination

of supervisory attention and ease of resolution created by the ring-fence. The second is that counterparties perceive a TVTF guarantee with the dealer bank being, in reality, no less risky. We find evidence that the first of these causes is the economic foundation for the reduction in perceived risk we identify. To gain insight we saturate our diff-in-diff estimation with bank-specific risk variables such as the Z-score and the distance-to-default. We find that the changes in repo rates demanded by counterparties are almost entirely explained by these risk metrics. We argue that this implies that a TVTF effect is not in evidence – borrowing interest rates reflect actual risk.

Deepening our empirical analysis we document that the reduced riskiness of the RFB group is driven by the RFB subsidiary. The nRFB subsidiary is not seen by third parties as more risky to an economically meaningful extent; we cannot rule out the conjecture that the borrowing costs of the nRFB are unaffected by the ring-fencing regime. We therefore conclude that ring-fencing has made third parties see the RFB subsidiary as measurably safer, and not damaged the nRFB subsidiary, aggregating to a material bonus in reduced borrowing costs at the group level. This result implies that the theorised negative effects of risk fencing – such as a reduced ability to transfer capital across the group – are outweighed by the theorised benefits such as improved resolution. This raises the possibility that third parties see ring-fenced groups as safe-havens even in (perhaps particularly in) times of stress. We will explore this below.

In the second part of the paper, we explore whether the RFB group does indeed have a reduced risk appetite as we have established is perceived by peers. We test whether the RFB groups demand higher interest rates of third parties for the loan of cash in a (reverse) repo transaction controlling for risk. Once again we use a diff-in-diff specification, controlling for deal size, collateral features, and bank balance sheet characteristics, and we include fixed effects including counterparty-by-day. We document that the RFB groups do charge higher rates to lend cash in repo transactions relative to other banking groups for loans of commensurate risk. Our empirical analysis therefore establishes

that the same counterparty on the same day pays higher rates to borrow from a dealer containing an RFB subsidiary as compared to other dealers.

We offer a theoretical model which explains the intuition as to why increased dealer risk-aversion translates into the dealer serving cash borrowers in the inter-bank market at higher rates in a competitive equilibrium. Empirically we analyse in detail a suite of competing possible mechanisms which readers might suspect underpin our results. We show that the RFB dealer banks do not reduce the volume of liquidity they supply into the market, suggesting that the increased prices demanded by such dealers are not a response to the dealers shifting up their supply curve. We show that the increased price demanded for a cash loan applies to reverse-repos which are nettable as well as those which are not, suggesting that balance sheet size restrictions via the leverage ratio, nor ability to net transactions explain the results. We show that the price increase demanded is not restricted to counterparties with a new dealer relationship, suggesting that reach-for-yield is not part of the explanation. We also show that the effect we document exists for large and smaller dealer banks, suggesting that balance sheet simplicity is not the cause of our results. These checks reinforce our conclusion that ring-fencing itself – the combination of facilitated supervision and optionality in resolution – has the effect of lowering the risk-appetite of the affected banks, that this is observed by counterparties, and manifests as a demand for higher recompense to RFB dealers to shoulder risk.

The third part of our paper documents that the ring-fencing bonus we identify is particularly pronounced during times of market uncertainty and financial crisis, as exemplified by the Covid-19 crisis and the associated lock-downs. The amplified bonus and 'safe-heaven' effects strengthen the liquidity provision benefits of a retail/investment banking separation. We compare the repo and reverse-repo rates in a diff-in-diff specification in which we interact the treatment of ring-fencing with individual months during 2020 to capture the Covid shock. We once again saturate the

empirical specification with the transaction, dealer and counterparty controls. We document that the reduction in the repo rates, that is the rates at which counterparties are willing to lend to the dealer banks, remains pronounced during the entire Covid stress period. During the height of the stress period we discover that this perceived reduced risk is acquired also by the nRFB subsidiary as well as the RFB subsidiary. That is the entire dealer banking group becomes identified as a high-quality counterparty. In stress times, the magnitude of the ring-fencing bonus is remarkable in economic terms: counterparties are willing to charge 11.76% less for the ring-fenced banking groups to receive their cash, and 58% less for the ring-fenced subsidiary relative to the other dealers at the announcement of the Covid lockdown. During the stress period the dealer bank, driven by the RFB subsidiary, demands higher prices to take on risk, so that the aversion to risk remains in this stress period. Our results suggest that the dealers containing a RFB are seen by counterparties as super-safe. We refer to this as the bank becoming a safe haven, to which counterparties are willing to lend at a discount during stress times. We corroborate our findings by documenting that counterparties do indeed deposit greater sums over stress periods in RFB groups who see increases in their wholesale funding and bank deposits.

Contribution to the literature

Our work contributes to three main strands of literature. The first is the study of how vulnerabilities in the safety and soundness of banks can be improved by structural changes in the form and governance of licensed banks. An extensive literature has explored whether breaking up banks, in the manner of the former Glass Steagall Act, contributes to greater bank safety. Some studies broadly find that not breaking up banks is value enhancing. In each case diversification is seen as valuable, which would seem to suggest that ring-fencing would be value destructive. Examples include Baele et al. (2007) using European data and Cornett et al. (2002) with U.S. data. In a

recent model, Williamson (2024) has theoretically suggested that ring-fencing can reduce moral hazard and make it less likely for banks to misrepresent the riskiness of their assets. However there is also literature arguing that combining an investment banking business with a retail bank increases overall risk. Examples in this vein include DeYoung and Torna (2013), Demirgüç-Kunt and Huizinga (2010) and Caprio et al. (2007), who in turn build on an earlier line of research focusing on the combination of retail banking with underwriting inside the same bank, a practice which was not permitted under Glass-Steagall.[5] The debate as to whether banks should be split between retail and wholesale sides might therefore be described as being at a stalemate. We propose an entirely new direction: ring-fencing is a structural intervention which falls short of full separation and represents an, as yet unstudied, middle way. Our contribution is to investigate if ring-fencing is a policy tool which can lower bank risk and so enhance financial system resilience. We are the first to address this question, and one of the first papers to exploit the ring-fencing reform (with Chavaz and Elliott (2023) and Bardoscia and Ka-Kay Pang (2023) as other exceptions).[6] Our contribution is novel not just because we use the ring-fencing intervention in the UK, but also because we study the soundness of the financial market by assessing perceived risk, and we do this by using prices from overnight and short duration interbank loan markets. This contrasts with the above literature which typically uses incidences of bank failures, which are rare, or equity prices, which mix long-term strategic considerations with current risk.[7]

Our second contribution is to extend the analysis of repo-market data to shed light on the information contained in repo and reverse repo prices. Repo markets are critical to the financial system. They are a key source of liquidity management and funding for banks and non-bank

[5] See Kroszner and Rajan (1994), Puri (1996), Gande et al. (1997), and Drucker and Puri (2005).

[6] Chavaz and Elliott (2023) document a pivot towards mortgage lending within the ring-fenced subsidiary and away from corporate banking in other subsidiaries. Bardoscia and Ka-Kay Pang (2023) analyse theoretically the equity reallocation and contagion effects of ring-fencing in an inter-bank network.

[7] A further approach to bank risk, different again from our focus on prices, is to use the value of options on each bank to infer their volatility (Swidler and Wilcox (2002)).

financial institutions alike (ICMA, 2019; Correa et al., 2020). The literature has shown that the inter-bank lending market is an early indicator of stress and identifies problems before market collapse; for example Ashcraft et al. (2011) and Fleming et al. (2010) make this case using data from the run-up to the 2007-8 Global Financial Crisis, while Copeland et al. (2021) argue bank deposits at the central bank can be similarly revealing. Repo market prices are informative as prices are negotiated bilaterally and repeatedly between informed parties (Ashcraft and Duffie (2007), Auh and Landoni (2022)). Repo dealers are not price-takers but have some market power allowing the prices charged to reflect the characteristics of the two contracting parties (Huber (2023)), and informed parties respond to news as to banks' soundness rapidly (Martin et al., 2018). These are features our work exploits. Recent work analyses repo spikes in both US (Paddrik et al., 2023) and UK (Hüser et al., 2023) repo markets, documenting pricing drivers of repo rates. The fragility of the short-term money markets has been documented both theoretically and empirically. Acharya et al. (2011) theoretically argue that a small change in the fundamental value of collateral could lead to dramatic changes in short-term debt capacity and a market freeze. Gorton and Metrick (2012) find that the concerns about bank solvency and collateral liquidity could result in higher haircuts and a market break-down.[8] We make two contributions to this literature. Our first contribution is to demonstrate how one can exploit the bilateral census-like data on repo transactions available in the UK to identify changes in risk perception market participants have of each other and the risk appetite they exhibit. Second we offer a simple theoretical argument which links repo and reverse-repo prices to the risk appetite of counterparties in competitive equilibrium between dealers.[9]

[8] An excellent introduction to repo transactions and their uses is offered by ICMA (2019) while Ball et al. (2011) describes the pattern of intraday liquidity management between banks and other financial market participants. See also Bank for International Settlements (1999), Armantier et al. (2008), and Bech and Garratt (2003).

[9] Our study develops a model of interbank loan pricing to establish the relationship between risk and repo prices in a competitive market. Theoretically Yang (2023) develops a model of intraday interbank lending to study the timing of trades, but without allowing for competition between the banks. That the extent of competition amongst lenders affects the price of loans is known in theory, and has been confirmed empirically by, for example, Hinzen (2023).

Lastly, we contribute to the literature on the implications of macroprudential regulations on stress in the short-term money markets and on financial stability. During times of stress counterparties avoid repo trading with banks who are seen as fragile or risky (Anbil, 2018). This creates scope for unintended consequences of capital regulation on the repo market: for example Kotidis and Van Horen (2018) and Allahrakha et al. (2018) argue that the leverage ratio discourages banks from undertaking low-margin activities, making it costlier to provide liquidity in the repo market and so weakening financial stability.[10] We assess the contribution of ring-fencing to financial stability in repo markets during times of financial stress, such as during Covid-19.[11] This work allows us to identify that ring-fencing can create a private sector bank which is seen by its peers as super-safe and so can contribute to financial stability when it matters most.

The paper proceeds as follows. We first discuss the institutional details of the repo market and the ring-fencing reform in Section 2. In Section 3 we develop a model of the inter-bank lending market allowing for risk-appetite and risk-perception. This section develops the theory underlying the empirical analysis in a parsimonious manner. Subsequently we describe the data we use from the Sterling Money Market (Section 4). There then follows, in Section 5, a discussion of the empirical design and strategy proposed whilst some identification issues are explored in Section 6. The empirical results and discussion follow in Section 7. In Section 8 we explore the mechanism behind our results; we compare the risk-appetite evidence from our data and its interpretation given by our model against other possible explanations. Section 9 considers the effect we find in stress scenarios and explores evidence that ring-fencing can create a safe haven for market participants.

[10] Another line of work studies the impact of the LOLR policies on systemic risk in the short-term money markets. For example, Jasova et al. (2021) use novel micro-level data and show that the lender of last resort (LOLR) policy leads to higher systemic risk as it leads banks to increase their bond holdings and pledge higher haircut bonds by the systematically important banks. Acharya et al. (2017) find that bank dealers with greater leverage and less collateral are more likely to utilize the lender-of-last report (LOLR) facilities during the financial crisis. Our findings suggest that ring-fenced banks are seen as a safe heaven in stress periods.

[11] See also and Avalos et al. (2019) who identify that repo access is important during times of stress. Hüser et al. (2023) explores repo clearing decisions during the recent stress period of Covid.

Section 10 offers some further robustness checks while Section 11 concludes. The data tables and figures are in Section 12 with some supporting tables in online Appendix A. In online Appendix B we include more discussion of competing theories and identify their short-comings against the data available.

2 Institutional Details

The Gilt repo market

A repurchase agreement (repo) is a form of short-term borrowing where one party sells securities, usually bonds, at a given price to a counterparty with an accompanying agreement to repurchase the securities at a specified price at a pre-determined time in the future. For the party that sells the securities and repurchases them in the future (cash borrower), the transaction is a repo. While for the party that buys the securities and resells them later (cash lender), the transaction is a reverse repurchase agreement, known as a reverse repo. If the cash lender demands a certain collateral (at an individual identifier (ISIN) level) as opposed to a general basket of collateral meeting certain criteria, then the transaction is called special. It follows therefore that if bank i conducts a repo transaction with bank j then bank i receives cash and is a borrower.[12]

The repo markets play a key role in the allocation of short-term capital in national financial systems on a day-to-day basis. They allow market participants to meet their short-term need for cash, while at the same time providing a low-risk vehicle allowing excess cash to be invested overnight or for other short durations.[13] In the UK most of the repo market uses gilts, that is UK Government bonds, as the collateral security. Tables 1 and 2 summarise trade and dealer characteristics in the domestic repo market. In the UK 80% of gilt repo transactions are overnight.

[12] A study of the UK repo market is available in Hüser et al. (2023).

[13] In the UK banks must maintain a cash position in the balance sheet by regulation. As this cash does not earn a return banks actively manage their cash position using Treasury operations on a daily basis.

Banks and dealer banks primarily use repos for liquidity management and intermediation. Liquidity management strategies are fairly stable in time, as they need to continuously meet regulatory requirements and even require pre-approval from the regulator. This can lead to broadly inelastic liquidity demand. In stress times, firms may also demand special collateral to meet their specific lending or collateral posting needs. Additionally, despite the short maturity, settlement demands can be large and can cause substantial disruption, as was evidenced during the UK mini-budget crisis of October 2023 when gilt prices decreased to such an extent that the Bank of England launched a major market intervention.[14]

Ring-fencing

As a response to the 2008 Financial Crisis, the Independent Commission on Banking (ICB) in the UK proposed banking reforms to reduce risk and moral hazard in the banking system.[15] The 2013 Financial Services (Banking Reform) Act in turn required large banks to ring-fence their retail banking from their investment and international banking operations. The goal of this separation is to protect the retail banks from the risks and failures of other subsidiaries within the banking group (Britton et al., 2016). It was also part of the broader agenda to reduce the negative externalities of bank failures on UK taxpayers. Under the new regime, UK banking groups with more than £25 billion of "core" (retail and Small and Medium Size Enterprises (SMEs)) deposits were obliged to restructure their businesses during 2018. The restructuring had to be approved by the Court during 2018 so that different banks were officially scheduled to be ring-fenced at different points in time[16]. If approved, the banks placed their retail and small business deposit-taking activities under common oversight which went on to become ring-fenced subsidiaries (RFB) on 1st of January 2019. Prohibited activities had to be moved outside the ring-fence and these subsidiaries formed

[14]For details on the UK mini-budget crisis see e.g., Hauser(2023) speech.

[15]See Final Report of the ICB (Vickers, 2011).

[16]We collect data on the specific day and time in 2018 when the bank was approved by the Court to be ring-fenced. The list of ring-fenced entities can be found here.

the nRFB. The legislation requires financial, management, and operational separation between the RFB and the rest of the banking group. That is, the RFB is expected to be financially independent from other subsidiaries within the group and hold enough capital to absorb shocks without relying on the financial support of the wider banking group (see Britton et al. (2016)).

The activities which are exclusively permitted in the nRFB include operations outside the EEA, dealing in investments as principal, commodities trading, and exposure to financial institutions. Both RFBs and nRFBs are allowed to have exposures to building societies and other RFBs, sell simple derivatives to corporates, building societies and other RFBs, and hedge liquidity, interest rates, currency, commodity and credit risks for their own activities. Firms were able to decide where they wanted to place the activities open to both nRFB and RFB, leading to larger or smaller RFBs and so implicitly different business models.[17]

Since January 2019 the ring fencing regime has been operational. A key objective of the national regulator with respect to ring-fencing is to minimise the risk that the failure of a RFB or of a nRFB could affect the continuity of core services provision.[18] Examples of these limitations include that RFBs need to meet prudential requirements such as capital adequacy and liquidity adequacy assessments on a standalone basis, and they have limited ability to transfer collateral or debt in the form of equity ("double leverage") between affiliates in the group and the RFB (PRA, 2016b,a). The RFB can also be subject to an additional System Risk Buffer (SRB) / Other Systemically Important Institutions (O-SII) buffer capital requirement, and has enhanced reporting requirements.[19] It follows that RFBs are subject to a tighter regulatory regime than a regular bank subsidiary.

[17]Further details are available in the Ring-fencing and Proprietary Trading Independent Review (Skeoch, 2022).

[18]See the Prudential Regulation Authority (PRA) objectives in respect to ring-fencing from CP 25/16 (PRA, 2016b).

[19]See Systemic Risk Buffer Rates, O-SII buffers and PRA Ring-fencing for further details.

3 A Simple Model of the Inter-Bank Repo Market

We present a simple model which allows the effects of risk aversion on the inter-bank repo market interest rate to be studied. This model offers the intuition which we will subsequently give to our empirical results.

There are two dealer banks, labelled $\{A, B\}$, and a counterparty borrower. The counterparty has a liquidity shortfall of size normalised to \$1. The counterparty goes to the wholesale repo market to satisfy this financing need.[20] The counterparty will default on this repo with probability c (likely close to zero) in which case the borrowing will not be repaid. With probability $1 - c$ the contracted repayment is made. The counterparty's taste preference between dealer banks is uncertain to other market participants. This is captured by the random variable ε which is modeled as uniformly distributed on $[0, 1]$. The preference cost incurred by the counterparty if she borrows from dealer bank A is $\varepsilon \cdot t$, while it is $(1 - \varepsilon)t$ if dealer bank B is used. This captures that dealer banks have some market power – they do not face perfectly elastic demand.

The dealer banks $i \in \{A, B\}$ have access to liquidity reserves in excess of the minimum required for regulatory reasons. If not lent to counterparties these excess reserves can earn return r equivalent to the return offered by the Central Bank (IOR). Dealer bank i decides on the rate ρ_i at which it will offer to lend to the counterparty. The dealer banks are in competition and the counterparty will select one of the banks to borrow from.

The dealer banks may be risk averse. The simplest way to capture this effect is to define the parameter $\alpha_i \geq 0$ for $i \in \{A, B\}$ and denote each dealer bank's objective function if the lending

[20] The model is simplified by assuming that the counterparty's demand for liquidity is inelastic. This is a close approximation to the regulatory demands imposed in the UK real-time gross settlement system (Ball et al. (2011)). However demand could be modelled as being elastic (e.g. adapting Yang (2023)) without altering the main results.

transaction yields a realised payoff net of the opportunity cost of funds of x as:

$$u_i(x) = \begin{cases} x & x \geq 0 \\ (1+\alpha_i)x & x < 0. \end{cases} \tag{1}$$

If $\alpha_i = 0$ then dealer bank i is risk-neutral. If $\alpha_i > 0$ then dealer bank i is risk averse. To see that α_i captures the extent of risk aversion consider a gamble which yields +\$1 and −\$1 with equal probability. The utility of this gamble is $-\alpha_i/2$ which clearly declines as the parameter α_i increases.

That banks should care about risk is not particularly controversial.[21] The model intuitions do not require us to microfound the risk aversion. In practice risk aversion is likely created by (i) supervisory pressure created by the regulator and (ii) expected value destruction which arises after a default event,[22] e.g. due to the costs involved in confiscating collateral. We hypothesise that both of these forces apply. This model captures the competitive tension between dealer banks, whilst encompassing differing risk aversion.

Equilibrium inter-bank repo rates

In this section we solve the model. Take as given the lending rates demanded by the banks: $\{\rho_A, \rho_B\}$. The probability that dealer bank A is chosen by the counterparty is

$$\Pr(\rho_A + \varepsilon t < \rho_B + t(1-\varepsilon)) = \Pr(2\varepsilon t < t + \rho_B - \rho_A) = \frac{1}{2} + \frac{\rho_B - \rho_A}{2t}. \tag{2}$$

Each dealer bank selects a rate to offer the counterparty which maximises their expected utility.

[21] For example, risk aversion is a foundational assumption in the literature which models banks as portfolio maximisers. See Freixas and Rochet (2008), Chapter 8, for a textbook treatment.

[22] As described in Keeley (1990) and in Thanassoulis (2012).

The expected utility of dealer bank A given the choice of bank B to offer repo borrowing at ρ_B is

$$E\left(u_A(\rho_A;\rho_B)\right) = \underbrace{\left(\frac{1}{2}+\frac{\rho_B-\rho_A}{2t}\right)}_{(\dagger)}\left[(1-c)(\rho_A-(1+r))-c(1+\alpha_A)(1+r)\right] \tag{3}$$

The term (†) captures the probability that dealer bank A is chosen by the counterparty. This probability is increasing in the rival's lending rate and declining in the own-bank offered rate. If dealer bank A is selected then with probability $(1-c)$ the repo loan will be repaid, this will yield a profit equal to the spread between the lending rate ρ_A and the opportunity cost of funds $1+r$. If however the repo is not repaid then the lending bank realises a loss of $-(1+r)$ on this transaction. This loss incurs an increased weight of $(1+\alpha_A)$ due to the risk aversion of the dealer bank.

The objective function (3) will be optimised by bank A. The first order condition in ρ_A can be derived by differentiating (3) with respect to ρ_A, and setting to zero. After a little simplification this yields:

$$(1-c)(t+\rho_B-\rho_A) = (1-c)\rho_A-(1+r)(1+\alpha_A c)$$

The same analysis can be repeated for dealer bank B. This yields a system of two equations whose solution in $\{\rho_A,\rho_B\}$ is the equilibrium of the market model. The set of first order conditions can be written in matrix form as:

$$\begin{pmatrix} 2 & -1 \\ -1 & 2 \end{pmatrix}\begin{pmatrix} \rho_A \\ \rho_B \end{pmatrix} = \left(t+\frac{1+r}{1-c}\right)\begin{pmatrix} 1 \\ 1 \end{pmatrix} + (1+r)\frac{c}{1-c}\begin{pmatrix} \alpha_A \\ \alpha_B \end{pmatrix}$$

We can now invert the initial matrix and so solve for the equilibrium repo rates as a function of

the model fundamentals. We denote this equilibrium with an * superscript:

$$\begin{pmatrix} \rho_A^* \\ \\ \rho_B^* \end{pmatrix} = t + \frac{1+r}{1-c} + \frac{1}{3}(1+r)\frac{c}{1-c}\begin{pmatrix} 2\alpha_A + \alpha_B \\ \\ \alpha_A + 2\alpha_B \end{pmatrix} \tag{4}$$

We can now interrogate the equilibrium repo inter-bank rates derived in (4). First we determine the rate of change in the repo rates as a function of the probability of a credit default event at the counterparty (c). Using (4) we have:

$$\begin{pmatrix} \partial\rho_A^*/\partial c \\ \\ \partial\rho_B^*/\partial c \end{pmatrix} = \frac{1+r}{(1-c)^2}\left(1 + \frac{1}{3}\begin{pmatrix} 2\alpha_A + \alpha_B \\ \\ \alpha_A + 2\alpha_B \end{pmatrix}\right) > 0.$$

It follows that if the probability of a credit default event in the counterparty increases, the dealer banks demand higher interest rates from the borrowing bank. The rate of change is close to linear when c is small, but as the default event becomes significant then any further increases in default probability have a significant and accelerating effect on the interest rate offered.

Now choose the labelling such that dealer bank A is weakly more risk-averse than dealer bank B : $\alpha_A \geq \alpha_B$. We define the lending rate gap offered to the counterparty in equilibrium to be given by $\Delta\rho^* := \rho_A^* - \rho_B^*$. Suppose that dealer bank A becomes more risk averse, i.e. α_A grows. To discern how this manifests on the lending rate gap we use (4) again to determine that

$$\frac{\partial\Delta\rho^*}{\partial\alpha_A} = \frac{1}{3}(1+r)\frac{c}{1+c} > 0$$

It follows that dealer bank A demands a higher rate of interest than its peers when offering to lend to the counterparty. Note also that this gap is independent of the strength of competition t.

We can also use our model to study how the market share of dealer bank A changes relative

to its peers if its risk aversion were to rise. The market share of bank A is given by (2). We can therefore define ΔV^* as the difference in the volume market share between bank A and bank B in equilibrium. We have

$$\Delta V^* = \frac{1}{t}\left[\frac{1+r}{3}\frac{c}{1-c}\right](\alpha_B - \alpha_A)$$
$$\Rightarrow \frac{\partial}{\partial \alpha_A}\Delta V^* = -\frac{1}{t}\left[\frac{1+r}{3}\frac{c}{1-c}\right]$$

We see that increasing risk aversion for bank A lowers the market share of bank A relative to her peers, but at a rate which is sensitive to the degree of competitiveness in the market. If the counterparty has strong preferences where she borrows from then t is large, and in this case the change in volume share is small.[23]

The effect of risk aversion therefore manifests most observably in the lending rate gap. We collect this discussion as:

PROPOSITION 1. *In the equilibrium solution of the indicative inter-bank model:*

1. *If the counterparty's probability of default decreases then the lending banks offer to lend at lower rates.*
2. *If a lending bank should become more risk averse then the lending bank increases the interest rate at which it chooses to offer a loan to the counterparty borrowing bank.*
3. *The sensitivity of market share to lending bank risk aversion is small when borrowers have strong preferences as to which lending bank to borrow from.*

This paper will present evidence from the behaviour of dealers and counterparties that suggests that ring-fencing has caused other banks to perceive banking groups which contain a ring-fenced

[23]Large t is likely to be the empirically relevant case as counterparties have preferences to maintain the spread of their interactions with dealer banks – Huber (2023).

subsidiary as safer (part (1) of Proposition 1). We will also present evidence that ring-fenced subsidiaries are more risk averse in their lending decisions (part 2 of Proposition 1). And we will note that the sensitivity of volume share to risk aversion is small (part 3 of Proposition 1) as one would expect in markets where clients have strong existing relationships and preferences between dealers (Huber, 2023).

4 Data

The primary database we exploit is the Bank of England regulatory Sterling Money Market Database (SMMD), covering the near-universe of secured sterling-denominated transactions backed against gilts between January 2016 to August 2021. To construct the SMMD the Bank of England collects money data from the banks, building societies, and major investment firms on their secured and unsecured sterling money market transactions. We observe the legal entity transacting, which allows us to identify the RFB and the nRFB trades. Interdealer repo transactions account for about 30% of deals. In dealer-to-client transactions dealers trade with a variety of counterparties – for example, hedge funds, pension funds, insurance companies, asset managers and money market mutual funds. The vast majority of these trades come from other financial institutions. Our sample only includes trades above £1 million, with one year as the longest maturity. We observe 24 active large banks in the market, which we refer to as dealers, where some of the reporting banks have RFB and nRFB subsidiaries.[24]

This database contains trade level information, including collateral and counterparty characteristics, which permits for a more granular analysis.[25] Since counterparties often transact with multiple dealers within very short time intervals, we can compare for the same counterparty and

[24]Due to data confidentiality we are not permitted to disclose further dealer information.

[25]In the supervisory available repo data such as Target2 and Fedwire, the counterparty identities are often unavailable, leading researchers to resort to matching algorithms (e.g. Furfine (2001)). The richer SMMD allows us to avoid this problem.

at the same time whether there are any persistent differences in the perception counterparties have of a given dealer or type of dealer (e.g. group contains a RFB subsidiary). Focusing on the same counterparty on the same day also allows us to systematically account for any time-varying macroeconomic confounding factors over time.

We focus on the dealer-client segment for two main reasons. First in dealer-to-dealer transactions, parties often take the role of a market maker and trade on behalf of an unknown third party. As our core interest is the pricing of risk in the repo market we would not be able to capture the source of this risk. Second, most dealer-to-dealer trades are settled on a CCP which removes counterparty credit risk, a focus of our work. We also exclude intra-group transactions, such as internal trades between the subsidiaries of the same group, and trilateral repo transactions. In both cases such trades do not allow us to extract a clear signal of the perceived riskiness of the RFB or nRFB.

Within the dealer-client segment we exclude repo transactions with States, government entities, trusts, and non-financial counterparties. The different business models of these entities would weaken our identification. In a similar vein, we drop the modest number of repo transactions with variable rates, pool, and multiple collateral because of the likely difference and complexity of the underlying pricing models. Finally, since our goal is to estimate the differential rates for the same counterparty across dealers, we only include transactions where the counterparty name is available. That excludes a minority of transactions where the counterparty name is not provided, for example due to privacy laws. We aggregate the clients to a parent entity level to capture, for each counterparty, the firm-specific determinants of repo market activity. This cleaning process leaves us with almost 2.4 million transactions over the studied period.

Dealer banks will both borrow from and lend cash to the financial institutions remaining in our sample: money market mutual funds, pension funds, hedge funds and the like. The dealer

banks include both UK, ring-fenced and non-ring-fenced, as well as large international banking groups which are domiciled abroad but with domestic UK subsidiaries or branches. Dealers can also have very different business models, including retail focused and large investment banks.[26] We observe simultaneous transactions involving different legal entities, though these entities are part of the same banking group. In our analysis we treat them as separate entities in the RFB/nRFB comparison, and we aggregate them at parent level in the group analysis.[27] Between 20 to 25% of ring-fenced groups' total repo transactions were executed by the RFB subsidiary - see Figure A.1. The ring-fenced bank dealers represent a significant part of the repo market as their aggregate repo volumes approximately represent 40% of the repo trades (Figure A.2).

We use trade information such as the repo rate, volume, trade maturity, haircut and whether the collateral was special or not. The securities provided by the cash borrower (bank i) in return for the short-term cash act as collateral. They provide protection to the cash lender, and would be sold in the event of default.[28] Our key variable of interest is the repo rate, which captures the rate offered to counterparty j who receives short-term cash against collateral from counterparty i. We control for macro-economic and bank-specific variables that will likely influence the repo rate. From Capital IQ we collect bank-specific variables known to affect prices such as bank size, capitalization, and the bank's liquidity coverage ratio (Acharya et al., 2022). We also use these variables to construct bank-specific risk measures such as the Z-score and distance-to-default (Altman, 2013). We complement collateral data with gilt-specific daily price data from Eikon. Finally we extract macroeconomic controls, such as inflation and GDP, from the Office of National

[26] Due to data confidentiality agreements we cannot list or provide identifying information on the dealer banks used in the sample.

[27] For example, a non-UK (foreign) banking group A can have investment branch A.1 and (UK deposit taker) subsidiary A.2 transacting. Perhaps A.1 acts as a market maker with direct connections in their country of origin, while A.2 may do domestic liquidity management or focus more on their UK clients. To capture these heterogeneities we control for both the individual institution (A.1 and A.2) and the parent (A) effects.

[28] Bank j lends less cash to bank i than the market value of the securities that i provides. This reduction is known as the haircut.

Statistics, and data on overnight interest rates is sourced from the Bank of England.

5 Empirical Design

Main model specification

We first investigate the impact of ring-fencing on the risk perception third parties have of ring-fenced banks. We study the interest rates at which third parties are willing to lend to ring fenced banking groups as expressed in daily repo transactions. Repo interest rates represent the cost of acquiring liquidity (i.e. cash) to a bank dealer.

If repo investors perceive the ring-fenced banking group to be less risky, we would expect, other things equal, the client to be willing to lend cash at a lower interest rate to RFB groups as compared to the rate demanded of dealer banking groups that are exempt from the ring-fencing reform. This reflects the theory captured in Proposition 1 as cash lending occurs through repo transactions.

We noted at least two reasons a banking group containing a RFB may be seen by third parties as less risky than other banking groups, controlling for the time-invariant bank-specific characteristics such as the business model and time-varying characteristics such as bank capitalization and liquidity. Firstly, it is possible that the supervision of RFB groups involves closer monitoring by the regulator and easier resolution if necessary. Secondly, third parties may perceive the RFB status as a signal of an implicit government guarantee.

As noted, however, there are also reasons to believe that there will be no change in third party perceptions of overall RFB group risk. This would be the case if the RFB subsidiary were a small part of the banking group and so had limited impact at a group level. Alternatively, any implicit regulatory support for the RFB might be perceived as a lack of support for the nRFB which might net out into a riskier perception of the ring-fenced group. Finally, ring-fencing may inhibit diversification to such an extent that risk rises.

To test the hypothesis that RFB groups can borrow at lower interest rates, we run the following baseline specification on repo transactions:

$$\begin{aligned} repo_{ijkt} = & \beta_1 \times ring\text{-}fencing_{jt} \\ & + \beta \times X_{ijkt} + \alpha \times X_{jt} + dealer_j \ FE + counterparty_i \times day_t \ FE + \epsilon_{ijkt}. \end{aligned} \tag{5}$$

The dependent variable in this specification, $repo_{ijkt}$ is the interest rate paid by subsidiary k of dealer banking group j to receive cash from client i on date t. We use a similar specification to extend the analysis to other non-price channels of adjustment to ring-fencing in the paper such as the transacted volume or the collateral characteristics such as the maturity and price volatility of the gilt collateral and the haircuts demanded.[29]

We define the indicator variable $ring\text{-}fencing_{jt}$ as one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. Our regulatory set-up ring-fences the UK banking groups with more than £25 billion of core deposits and thus allows us to classify our dealer banks into treated and control groups[30]. We also believe the timing of the Court Approval to be unlikely to be manipulated by individual banks, so we treat it as exogenous and exploit the inter-temporal variation in the treatment in our high-frequency analysis. Our central hypothesis is that ring-fencing reduces the perceived risk of a dealer banking group in the eyes of outside investors, therefore we anticipate $\beta_1 < 0$.

To control for client risk and collateral demanded, we include counterparty fixed effects as

[29]The variables contained in X_{ijkt} controls for the trade characteristics such as haircut size to ensure that we compare equivalently covered repo borrowing. In some specifications, we control for other trade characteristics such as the size and maturity of the repo transaction, collateral maturity, and the standard deviation of the collateral price. Collectively these controls ensure that any changes at the time of the ring-fence in the maturity or collateral included in repo transactions cannot be the cause of our results. In addition, X_{jt} controls for quarterly bank balance-sheet characteristics at the group level such as total size, capitalisation, and the liquidity coverage ratio in addition to the credit rating.

[30]The 25 billion of core deposits threshold is imposed on a three-year-rolling window, which makes it unlikely to be manipulated by the individual bank dealers. Furthermore, our bank dealers are very large multinational banks with a large variety of funding sources, with the UK-deposit-based threshold likely exogenous to the overall business model and funding structure of the consolidated banking group as a whole.

in Khwaja and Mian (2008). For the same counterparty, we compare the cash lending to dealer banking groups subject to ring-fencing with other similar dealers, and by $counterparty_i \times day_t$ fixed effects we capture any short-term variations in the risk and collateral demand at the counterparty level on any given day. That is, we compare the repo transactions of the same counterparty on the same day across banking groups containing RFBs and ones that do not contain RFBs. We add our $counterparty_i$ FE at the client-parent level to ensure daily variation at the counterparty-level. We also saturate our specification with $counterparty\ type_{ik'}$ fixed effects at the client-subsidiary level to account for the differences in the business model of the different counterparties (*e.g.* hedge fund, pension fund, insurance company, or money market mutual fund) that belong to the same client i. The dealer fixed effects ($dealer_j$) capture time-invariant business models of the dealer banks, such as the cross-sectional differences in retail deposits. The variable ϵ_{ijkt} is our error term. We cluster standard errors at the cash lender level to account for the fact that changes in repo lending terms are correlated across cash lenders.

Our second step is to isolate any effect at the subsidiary level, and so disentangle the between-subsidiary effects of the same banking group. We therefore aim to distinguishing between third party perceptions of the RFB subsidiary versus the nRFB set of subsidiaries, as we are able to observe the transactions separately.[31]

Since repo is one type of activity allowed both inside and outside of the ring-fence as long as it is for liquidity purposes (and not market-making), our setting helps us analyse the heterogeneity of the effects across subsidiaries. To test for this, we run the specification (5) by including RFB

[31]For example, ring fenced group X is a UK-incorporated bank with the subsidiaries consolidated under the name of X_{legal}. Since month t 2018, Group X set up a ring-fenced bank, X_{RFB} as a wholly-owned subsidiary. The ring-fenced entity includes personal banking and services to SMEs for UK clients. The non-ring-fenced entities are called X_{NRFB1} and X_{NRFB2}, and include international and investment banking businesses.

and nRFB dummies:

$$repo_{ijkt} = \beta_1 \times RFB_{jkt} + \beta_2 \times nRFB_{jkt} \tag{6}$$
$$+ \beta \times X_{ijkt} + \alpha \times X_{jt} + dealer_j FE + counterparty_i \times day_t \ FE + \epsilon_{ijkt}.$$

In equation (6) the variable RFB_{jkt} is one if the cash which is received in the repo by subsidiary k of dealer banking group j is ring-fenced at time t, and zero otherwise, where the index k denotes the subsidiary level and not the consolidated group level. Thus, specification (6) allows us to compare counterparties' views of riskiness of the RFB subsidiary and the remaining set of nRFB subsidiaries as compared to groups which are not affected by the ring-fencing regulations in the UK. We hypothesise that the implementation of ring-fencing causes a reduced risk perception of the RFB subsidiary by third parties (Proposition 1, part 1) captured if:

$$\beta_1 < 0.$$

We are more agnostic as to third parties' perception of the riskiness of subsidiaries outside the ring-fence: denoted nRFB. If the nRFB is denied the promise of an implicit bailout then it might be seen as riskier than would otherwise be the case. This would cause third parties to demand higher rates: $\beta_2 > 0$. In the null however $\beta_2 = 0$ which would hold if the separation would not affect the nRFB part of the group. We explore further the economic mechanisms underlying our results in Section 8, and robustness in Section 10.

Having explored third-parties' perception of the riskiness of ring-fenced dealer banks, we turn to the risk-appetite of the ring-fenced dealer banks. We study whether the risk appetite of the ring-fenced banking groups has been affected by the structural regulatory intervention. We test if

other-things-equal, a RFB group lends cash more expensively than non-ring-fenced banking groups. If a RFB group had a reduced risk appetite then the group would charge higher interest rates, as predicted by Proposition 1, part 2. We note that there may be other reasons why a RFB group may lend more expensively beyond risk appetite, which we explore in Section 8. To investigate whether ring-fencing impacts the price at which a RFB group lends cash, *i.e.* the price at which RFBs supply liquidity, we run the following specification on the reverse repo transactions:

$$\begin{aligned} \textit{reverse repo}_{ijkt} = & \beta_1 \times \textit{ring-fencing}_{jt} \\ & + \beta \times X_{ijkt} + \alpha \times X_{jt} + \textit{dealer}_j \ FE + \textit{counterparty}_i \times \textit{day}_t \ FE + \epsilon_{ijkt}. \end{aligned} \tag{7}$$

The dependent variable is the interest rate on the reverse repo transaction in which dealer j provides cash to (i.e. lends to) client i on date t. The control variables X_{ijkt} include again haircut size and in some specifications the size and maturity of the transaction, collateral maturity, and the standard deviation of the collateral price. X_{jt} accounts for the time-varying characteristics of the parent bank. We again include $\textit{counterparty}_i \times \textit{day}_t$ fixed effects.

Our central hypothesis is that ring-fencing increases the price which the RFB group demands of borrowers for liquidity. This would follow if we establish that in (7)

$$\beta_1 > 0. \tag{8}$$

We seek to isolate the effect to the subsidiary level. We proceed analogously to equation (6) and conduct the following analysis by replacing the ring-fenced dummy at the group level with the RFB and nRFB indicators at the subsidiary level:

$$\begin{aligned} reverse\ repo_{ijkt} =& \beta_1 \times RFB_{jkt} + \beta_2 \times nRFB_{jkt} \\ &+ \beta \times X_{ijkt} + \alpha \times X_{jt} + dealer_j\ FE + counterparty_i \times day_t\ FE + \epsilon_{ijkt}. \end{aligned} \tag{9}$$

The RFB subsidiary k of dealer bank j demands higher prices to lend cash in the repo market if $\beta_1 > 0$. Equation (9) also allows us to extract the impact of ring fencing on subsidiaries outside the ring-fence boundary, the nRFB, through β_2.

The Ring-Fencing Bonus in times of market stress

Repo spread spikes during crises can be caused by information frictions and market segmentation (Paddrik et al., 2023). Spreads can also rise due to a perceived increase in counterparty credit risk. While in normal periods the counterparty risks associated with (overnight) repo transactions are low, in stress periods this might not be true. Stress periods are therefore a useful laboratory to evaluate the market perception of ring-fenced entities.

We hypothesize that the increased safety of RFB groups becomes more prevalent during market stress. If so then counterparties will be willing to lend to RFBs at a discount in stress times to capture the lower counterparty risk, i.e. market participants turn to RFBs as a safe heaven. Second, RFBs as liquidity providers will be able to charge higher rates to price-in the premium of trading with a reliable and safe dealer.

We test these hypotheses during the Covid-19 pandemic "dash-for-cash" (Czech et al., 2021), by augmenting the main model specifications with interaction terms during the peak lockdown months in the UK. This is discussed further and explained in Section 9.

6 Identification Issues and Stylized Facts

In this section, we discuss stylized facts and relate them to our empirical analysis and identification design. Table 1 reports summary statistics on the types of dealers and counterparties active in the UK repo market during the study period 2016-2021. Panel A presents the distribution of repo market participants and repo trade pairs. There are over 20 dealers at group level for both repo and reverse repo transactions, trading with approximately 3200 and 5000 counterparties in repo and reverse repo respectively. Our main analysis includes over 2700 dealer-counterparty pairs.

End-users actively build and diversify their transactional relationships in the intraday liquidity trades, as exemplified in Panel B of Table 1. Counterparties, as measured at group level, trade on average with 44% of all dealers in one day. We obtain similar numbers at higher aggregation levels (monthly, yearly). Very few counterparties trade with only one dealer and most of them diversify their overnight trades across different dealers. This gives enough variation for our identification strategy when comparing the rates charged to different dealers by the same counterparty in the same day in these bilateral transactions, controlling for any counterparty-related variation such as overnight liquidity and collateral demand. In all our regression specifications we control for the counterparty parent, consistent with the empirical literature. As some parents have multiple counterparty entities trading in the repo market, our empirical set-up allows for a rich within-counterparty-day variation during the sample period without time gaps in trading. This reduces any potential sample selection bias that may arise in our strict specification with counterparty $\times$ day fixed effects.

Table 2 presents the general characteristics of the trades in the UK repo market. Panel A presents the sectoral split of counterparties present in the market. Note that there are numerous parents with legal entities trading in repos spanning across sectors - an example can be a group with a pension fund, a bank and a hedge fund business. Most counterparties active in the repo

market belong to the other financial counterparty category (78%). To account for the different business models of counterparties, we control in all our regressions for the type of the counterparty at the entity level to absorb any subsidiary-level variation within the same parent firm, and we exclude trades done by non-financials.

Panel B of Table 2 reports that around 90% of repo trades have overnight maturities but a small fraction also have maturities of a few months or weeks, with a maximum of one year.[32] We also find that most dealer-counterparty pairs trade very frequently both intraday and during a given week. As the repo lending price is set by the informed parties and renegotiated bilaterally, our baseline tests aim to measure the high-frequency variation of risk of the dealers using millions of pairwise transactions.

In Table 3, we report the summary statistics for the trade characteristics in repo (Panel A) and reverse repo (Panel B) transactions. We note a large variation in the deal rates of the UK gilt collateralised transactions, with very large repo trade volumes and limited dispersion.[33] In our baseline specifications we focus on the repo rates rather than haircuts, not only because most gilt collateral have no reported haircuts, but also because of the known reporting accuracy issues of haircut values.

7 Empirical Results

In this section we outline two of our three key results: (i) the perception by third parties of RFB risk, as measured via borrowing costs of repo transactions; and (ii) the risk appetite of RFBs as measured via lending costs of reverse repo transactions.

The ring-fencing reform imposes a ring-fence on the banking groups with above £25 billion

[32] We group the overnight, tom/next, and spot/next repo deals as overnight transactions. Tom/next repo have an opening leg tomorrow and are settled on the next day and spot/next trades settle two days after the transaction day.

[33] In the UK repo market, the prices are negotiated bilaterally without a specific overall market rate benchmark.

deposits, giving us a treatment and control group. In Table 4, we report the pre-treatment characteristics of these banks. Panel A captures that the treatment and control group are broadly similar in terms of size, total deposits, total equity, ROA, cost-to-income, liquidity coverage ratio, Tier 1 Capital Ratio, and price-to-book. The banks subject to ring-fencing were however somewhat less profitable and had lower market-to-book ratios than unaffected banks active in the repo market.[34]

7.1 The Ring-fencing Bonus: groups containing a ring-fenced entity seen as less risky

We proceed with our main analysis. We first evaluate the perception of RFB risk by third parties, by measuring the costs of borrowing cash at i) group level and ii) subsidiary level.

We study whether repo investors perceive ring-fenced banking groups as less risky, *ceteris paribus*, after court-approval and subsequent legal imposition of the ring-fence. As discussed above, on the one hand ring-fencing focuses supervisory attention on the RFB, facilitates resolution and may be a signal of enhanced government support. The net result would be a safer banking group. On the other hand, the structural separation into separate subsidiaries may erode the diversification benefits across different types of business operations and reduce implicit guarantees for subsidiaries outside the fence. If the first effects dominate and repo investors perceive the ring-fenced banks to be safer, then we would expect them to lend to the ring-fenced banking groups at lower rates relative to other banks after ring-fencing (as reflected in part 1 of Proposition 1).

We test this hypothesis by running specification (5), with results presented in Table 5. We see that across all specifications, the difference-in-difference estimate (the coefficient on $ring\text{-}fencing_{jt}$) is negative, and statistically significant. This suggests that the interest rate at which counterparties are willing to lend to ring-fenced banking groups declined. That is, counterparties became willing

[34] In subsequent robustness checks we restrict the sample to sterling-deposit-taking banks and match our treatment and control groups based on a rich set of pre-treatment bank characteristics using a series of propensity-score matching techniques. See the discussion in §7.1.

to pay a markup to lend to the ring-fenced banks after ring fencing – such loans are of more value to the counterparties *ceteris paribus*. In Column 1, the baseline specification suggests that the same counterparty on the same day lends cash at 0.885 basis points (3.54%) less relative to the median transaction rate (0.00885 × 100 / 0.25) if trading with a ring-fenced group relative to other dealer banks after the ring-fencing reform. This decline is robust to dealer fixed effects that control for time-invariant bank specific characteristics such as business model and liquidity management (columns 2 – 4). In Columns 4 and 5, accounting for the size of the transaction and collateral characteristics such as maturity, haircut, and price volatility leaves the coefficient of interest largely unchanged and so still negative and significant. Collectively the results support the leading interpretation that repo investors see banking groups containing a RFB as being less risky after the ring-fence. This perception of reduced risk translates into a group-wide reduction in the cost of borrowing: a Ring-fencing Bonus.[35]

We can see the ring-fencing bonus at the banking-group level dynamically by estimating our main model specification (5) in a Granger type dynamic panel regression with lag and lead coefficients relative to the ring-fencing completion date (January 2019) in years. We plot the estimated betas and their respective confidence intervals in Figure 1, Graph A.[36]

A live concern is that the perceived risk reduction enjoyed by the ring-fenced group is due to the RFB itself, whilst the nRFB (in the same banking group but outside the ring-fence) is perceived as riskier.[37] As we noted above and explore further, the public announcements during the construction of the ring-fencing regime highlighted the criticality of domestic retail banking infrastructure. An implication some might draw is therefore that the nRFB is less critical to the domestic economy.

[35]The data set granularity allows for a tight estimation of the price reduction counterparties are willing to offer RFB groups when lending cash. An implication of counterparty x day fixed effects is that the reductions are offered by the largest clients who conduct repo transactions with multiple dealers in one day. We explore whether this price reduction is present and measurable in even the smallest counterparty clients in the robustness section (Section 10).

[36]The results are similar if the analysis is done over quarters instead of annually – Figure 2.

[37]See for example Ervin (2018) who argues that the reduced access to deposit capital can make the international part of the bank more risky.

Perhaps therefore third parties see the nRFB as a more risky proposition, shorn (if the RFB has one) of a government guarantee, and so driving up its cost of borrowing.

To study this we run the baseline specification by interacting the ring-fencing dummy with the RFB and nRFB subsidiary indicators respectively, as explained in (6). We report the results in Table 6. We show that the RFB subsidiary benefits from a reduction in its borrowing rates, whilst the nRFB does not. The impact on the nRFB is either very small or statistically insignificant in columns 1 – 5. Note however in Table 6 that the coefficient measuring the impact on the ring-fenced subsidiary (RFB) is negative and significant in all specifications. Thus the RFB subsidiary within the group enjoys lower rates when it needs to borrow cash. Strikingly, the impact on the ring-fenced subsidiary is almost three-times larger in economic terms (7.41% relative to the median repo rate).

These results suggest that while the average reduction on the repo rates at the banking group level is due to the RFB, the rest of the banking group does not face a material adverse impact on its costs of borrowing.

Propensity-matched control group

This section reports a key robustness test. Our empirical set-up gives us an exogenous threshold (£25 billion of deposits) above which the dealer banks are ring-fenced. This threshold is on a three-year-rolling-basis and imposed on the large multinational banks with global operations and thus we take it as exogenous to the global dealer banks. We further exploit the inter-temporal variation in the Court approvals for ring-fencing for sharper identification. In this section we take one more step and we match our treatment group based on a rich set of pre-treatment bank characteristics using nearest-neighbour matching with the probit method (Table 4). We find in the first column of Table A1 that with the propensity-score-matched sample, our results remain quantitatively and qualitatively similar to those in our main specification discussed above. We conclude that the rich set of covariates, including the counterparty $\times$ day fixed effects, control for the relevant confounding

factors delivering a robust estimation.

Column 2 of Table A1 restricts the analysis to 2018 during which banks were approved by the court to establish a ring-fenced subsidiary. This somewhat reduces our coefficient to -0.01, suggesting that the effects gradually materialized after the court approval. We will explore whether court approval or legal implementation is most germane shortly.

In Column 3, we collapse the time-series of the repo rates into the pre- and post-event period. This mitigates potential concerns that serial correlation with the differences-in-differences approach may lead standard errors to become inconsistent (Bertrand and Mullainathan, 2004). We calculate, for each dealer-counterparty pair, the average rate charged to the dealer bank before and after the implementation date (1st January 2019) by their counterparties in the repo transactions. Our treated dummy is one if the dealer bank became ring-fenced in 2019. We show in Column 3 that our first-differences estimate becomes stronger and doubles in economic magnitude. This again offers strong support for our results.

7.2 Ring-fenced banks have a lower risk appetite

Next, we analyse the risk-taking behaviour of RFBs, as measured by lending choices and interest rates charged to third parties when lending cash via reverse repo transactions. We study i) the group level and ii) subsidiary level effects and drivers.

We evaluate the impact of ring-fencing on the risk appetite of banking groups by measuring the changes in the price of liquidity in reverse repo transactions. We analyse the rates at which dealer banks choose to lend cash in the short-term repo markets after the imposition of the fence, maintaining the suite of controls as described in Section 5.

Our analysis relies on the observation that *ceteris paribus*, greater risk aversion on behalf of the repo dealers would lead to larger spreads when lending (part 2, Proposition 1). Repo lenders

would require greater returns for the risks they run. Paligorova and Santos (2017) use a similar line of reasoning for corporate loans in the US.[38]

We run our diff-in-diff baseline specification (7) on the subset of reverse repo transactions. As noted in Section 5 we include dealer fixed effects to account for the time-invariant characteristics of banks such as liquidity management and collateral demand. We also add *counterparty* × *day* fixed effects to control for borrower quality at a daily level. Our tests therefore compare the change in the price demanded for cash lending provided by the ring-fenced dealer banks relative to other dealers for the same counterparty in the same day.

Table 7 reports the main results. In all specifications the interest rate demanded by ring-fenced banking groups when entering reverse repos has increased, as our coefficient of interest on $\textit{ring-fencing}_{jt}$ in Table 7 is positive and statistically significant at the 1% level. In the specifications excluding dealer fixed effects, Column 1 shows that controlling for the counterparty and trade day, the ring-fenced dealers provide cash at 1.43 basis points (an increase of 5.71% relative to the median transaction rate that is 0.0143 × 100 / 0.25) higher relative to the unaffected dealers after the implementation of ring-fencing. Once again, we emphasise that this is not driven by differences in the business model as the result holds even if the dealer fixed effects or controls are present (columns (2)-(5)). Furthermore, when we incorporate trade-level controls and account for collateral characteristics such as maturity and haircut in columns (4) and (5) the results remain quantitatively similar.

Next we evaluate if the risk appetite result is driven by a reduced risk appetite on the part of the RFB subsidiary only. To test for this possibility we run the specification (9) by replacing the term ($\textit{ring-fencing}_{jt}$) with the legal subsidiary RFB and nRFB indicators respectively, with results

[38] Paligorova and Santos (2017) document that U.S. banks with greater risk appetite have charged lower rates in corporate loans during periods of low interest rates. That is, they argue that a stronger risk appetite has led banks to under-price corporate loan risk, requiring lower credit risk premia relative to the other banks. This mechanism is a reflection of part 2 of Proposition 1.

in Table 8. In all the specifications considered, the nRFB also charges a higher interest rate when entering a reverse repo transaction after ring-fencing when compared to the control of banking groups which do not contain a ring-fence in the group. This result suggests that the increase in the cost of provision, and so the reduction in risk appetite, extends beyond the RFB to encompass the entire banking group.

This result is strong evidence that the fears which some have expressed (e.g. Ervin (2018)) that the nRFB may be rendered risky and risk-loving by ring-fencing has not been experienced in reality.

8 Mechanism

Our explanation for the repo pricing results we have described above is, as modeled in Section 3, that creating a ring-fenced subsidiary has altered the risk aversion of the banking group, and this in turn is reflected in the behaviour of other market participants. Which specific part of the ring-fencing regime's implementation (e.g. changed supervision, more credible resolution, alteration to legal default in resolution) is the source of the altered risk attitude, or whether all constituent parts are required, is a matter for further research. Our objective in this paper is to offer evidence that the ring fencing regime has generated a bonus for the affected groups by making them behave as if, overall, they have a reduced risk appetite, and this has made other banks see the whole affected group as safer than otherwise.

However, risk aversion (as per the model in Section 3) may not be seen by some as the right explanation for the changes in repo and reverse-repo pricing costs we have documented within ring-fenced groups. Possible alternative theories could be:

1. Any lower risk perception is perhaps due to a regulatory TBTF guarantee and not ring-fencing.

2. Any increased costs third parties experience are perhaps due to reduced liquidity from ring-fenced banks.
3. Ring-fencing has affected the ability of banking groups to net-off liabilities and perhaps this explains higher borrowing prices.
4. Ring-fenced entities are perhaps more exposed to leverage ratio rules and this has altered the prices at which these banks supply liquidity.
5. Ring-fenced banking subsidiaries have a simpler balance sheet which allows them to borrow more cheaply, perhaps explaining the results.
6. Ring-fenced subsidiaries perhaps alter their choice of counterparties and so engage in a '*reach-for-yield*' which might explain our results.
7. Ring-fenced subsidiaries are perhaps more reliable and so charge a reliability premium.
8. Banks argued against ring-fencing and so ring-fencing cannot be a bonus.

We will explore all of these hypotheses. We report the evidence for and against theories 1 to 3 inclusive in this Section. The discussion and assessment of theories 4 through 8 are contained in Internet Appendix B. We will find that all these alternatives have flaws and in our view fail to explain the repo market evidence we have documented.

8.1 Is ring-fencing a bail-out guarantee?

It has been suggested that the risk reduction third parties perceive in ring-fenced banking groups is real, but not caused by the economic implications of ring-fencing *per se*. Rather some argue that the effects we identify reflect market participants' inference that a government bail-out guarantee applies to banking groups which contain a ring-fenced entity.

In support of this theory recall that the report which established the basis for ring-fencing in the UK made clear that retail banking was 'vital', as we noted in the quote from the Independent Com-

mission on Banking recorded in the Introduction.[39] The assertion that the ring-fenced providers of retail banking services are *vital* suggests to some that the government will bail out these banks if needed. If this hypothesis is true then RFBs need not be any safer in terms of objective economic fundamentals, but instead enjoy a perceived enhanced probability of government support.

We examine this possibility in two ways. We first study whether there is evidence that ring-fencing lowered objective risk measures for the banking group, which in turn can explain the lower interest rates at which the ring-fenced group is able to borrow. If the borrowing rates are explained by objective risk measures then there is no explanation gap left for a contested *too-big-to-fail* theory to fill (Acharya et al. (2022)). To this end we construct two risk measures for the banking group, the Z-score and distance-to-default, and we incorporate them into our baseline specification in Table 9.[40] Columns 1 and 2 consider the distance-to-default, and Columns 3 and 4 study the Z-score. We therefore seek to capture reasonable economic drivers of the price of risk in a repo transaction. We show that in all specifications the impact of ring-fencing on repo rates is no longer present when we control for book- and market-based measures of bank risk. The risk measure (Z-score or distance-to-default) is always highly significant in explaining the rate at which the group containing the RFB subsidiary is able to borrow. This suggests that the reduction in the cost of repo is a by-product of real economic fundamentals in the form of bank risk and is evidence against a TBTF hypothesis.

Our second way to study the TBTF hypothesis is to investigate at which point in time the ring-fencing reform impacts repo borrowing rates. We horse-race the court date with the implementation

[39]The ICB, Independent Commission on Banking, see Vickers (2011).

[40]The literature has used a variety of measures based on the market and accounting data to capture bank risk. Book-based measures of risk include the Z-score. The Z-score is inversely related to the probability of bank insolvency and captures the distance from insolvency (Roy, 1952). It is calculated as the return on assets plus the capital asset ratio divided by the standard deviation of asset returns. Separately, distance to default is a market-based measure and is based on the Kealhofer - Merton - Vasicek (KMV) model. There, we derive the banks' asset value and asset volatility from equity value and equity volatility using daily observed share prices. The distance to default is calculated as the expected value of the banks' assets, taking (maturity-adjusted) debt into account, and divided by asset volatility over a 1 year horizon.

date in our baseline specifications (5) by creating two dummy variables. The first is our original $ring\text{-}fencing_{jt}$ dummy that takes a value of one after the UK courts and regulator approve the structure of the RFB for a given group.[41] The second dummy variable is $implementation_{jt}$, an indicator variable that is one after the legal ring-fencing start date in January 2019. If a perceived declaration of government support is the cause of the perceived risk reduction then we would expect the legal entity approved by the courts and the regulator to benefit immediately and fully from this perceived bailout guarantee. This would imply that the costs of borrowing through repos should be lower for the RFB group after court approval, whether the legal regime has completed the associated formalities (*i.e. implementation*) or not.

The results of this analysis are given in Table A10. In Column 1 and 2 of Table A10, we show that dealer banks subject to ring-fencing appear to borrow at lower rates relative to unaffected dealers following the approval of the ring-fencing transfer. This would be consistent with a TBTF explanation, if it survives more detailed analysis.

However, in Column 3 to 5, our most detailed specifications with the counterparty, trade, and collateral controls, we find that the impact of ring-fencing on the repo rates becomes insignificant after court approval but before implementation. Rather, we observe from columns 3 to 5 that when we add in controls to avoid confounding factors, we discover that only after the implementation of the ring-fencing as an economic and legal reality does the RFB group enjoy lower borrowing rates from counterparties. This suggests that the ring-fencing had first to be implemented in law before the reduction in the repo rates and risk perception occurred. Hence, ring-fencing appears to lower risk due to economic fundamentals and not due to an inferred assumption of a government guarantee.

We conclude this section by noting one more argument against the TBTF hypothesis. Had

[41] This is the event date used in the benchmark analysis detailed in Section 7.1, noting that the post-event time period then extends to the end of the sample period.

TBTF been the driving issue then we would expect the entity enjoying the government guarantee to take extra risk as its cost of capital tied to risky projects is reduced (Thanassoulis and Tanaka, 2018). However this effect is absent: the main result of this paper discussed in Section 7 is that the ring-fenced banking group is rewarded more, and requires a larger reward, to take on the same level of risk.

We therefore conclude that the TBTF hypothesis is not supported as an explanation for our results.

8.2 Do RFBs charge more due to reduced liquidity?

This hypothesis is directly testable by seeking evidence of any effect from ring-fencing on the volume of liquidity supplied by RFBs or their group. In particular we can test if RFB groups reduce their supply of liquidity into the repo market as compared to their non-RFB peers. This is achieved by replacing the dependent variable in our baseline specification (5) with the natural logarithm of the reverse repo volume. We therefore search for evidence that ring fencing affected repo volume shares, and we report our results in Table 10. Across all specifications our coefficient of interest is very small and statistically insignificant. Thus we find no evidence that the affected dealers lend smaller volumes in the repo market, controlling for the counterparty in the same trading day. Ring-fencing has not, as far as we can detect, reduced the repo market share of RFB groups relative to their peers, but it has made this cash more expensive. This is consistent with results 2 and 3 of Proposition 1 given the preferences counterparties have to maintain the spread of business they do across dealer banks (Huber (2023)).

We have found that ring fencing does not lead to any change in the volume share of repo transacted (Table 10). We extend this analysis and consider whether there is a change in aggregate volumes. We test this by controlling for aggregate liquidity in our baseline specifications and in a

further specification interacting our aggregate liquidity measures and treated × event dummy. The results are offered in Panel B of Table A9. We do not find any evidence that the repo price effects are altered by changes in aggregate repo volume (Columns 1 and 2), nor that changes in liquidity volume are relevant for the repo price effect (Column 3).[42,43]

So we find no evidence in support of a reduced liquidity explanation for our results.

8.3 Theory that ring-fencing inhibits netting, raising costs

The ability to net liabilities off against assets allows the risk exposure of a bank to be calculated at a net level as opposed to a gross level. As the net level is smaller this reduces the required regulatory capital a bank needs to hold and so lowers costs. If ring-fencing impairs netting in a consequential manner then it would raise the ring-fenced entity's cost, and so this could explain the higher price which the RFB demands when lending liquidity in the repo market.

A repo and a reverse repo transaction are nettable if they are transacted with the same counterparty on the same day and subject to the same settlement and maturity dates. Netting multiple transactions is pervasive in the trades cleared by the CCP, and is also prevalent in the bilateral dealer-client markets (Gerba and Katsoulis, 2021). We consider the nettable feature of repo transactions in Table A4. We separate out repo transactions which are nettable and we search for the repo pricing effect of the ring-fenced group in this subset of trades. This analysis is reported in Columns 1 and 2. Both columns show that the RFBs still receive repo cash at more attractive terms after ring-fencing even if we just focus on nettable transactions. This is direct evidence that nettability is not the cause of the results we identify.

[42] In Column 4 of A9 we account for the possibility that certain types of risky collateral may have been more affected by the ring-fencing reform. To do this we run the additional robustness check where we interact treated × event with the high-price volatility dummy, controlling for any differential effects of the reform on the riskier gilt segments. We find that the ring-fencing bonus is particularly pronounced for high volatility collateral.

[43] We study the long-term dynamics of volume changes at the ring-fenced groups in a dynamic regression adapted from (5) with respect to the ring-fencing completion date of January 2019. Graph B of Figure 1 depicts the result and confirms the lack of volume response.

We therefore find no evidence in support of an alternative nettability hypothesis.

9 Ring-fenced groups as safe heaven? The ring-fencing bonus in stress times

Short-term wholesale funding such as repo can become an unstable source of funding for banks. Fragilities in the short-term wholesale funding market can lead to sudden stops and dry-ups, resulting in substantial reductions in credit supply (see *e.g.*, Pérignon et al. (2018) or Iyer et al. (2014)).[44] At times of stress therefore banks will prefer to transact with institutions they perceive as safer and with lower counterparty credit risk. In this section we study the impact of ring-fencing on the sensitivity of counterparties' repo borrowing from RFB groups during periods of market stress.

9.1 Does 3rd party low risk-perception survive in stress times? Covid-19 Shock

We test whether the ring-fencing premium survives, or even becomes more pronounced, during periods of enhanced financial distress and market uncertainty. We anticipate that the ring-fencing bonus we have identified is likely to become more pronounced in stress times for the following reason. We established in Section 8.1 that the perception of reduced risk enjoyed by the RFB is likely due to enhanced supervision and improved resolution, and not due to TVTF implicit guarantees. During stress times, such as the recent Covid emergency, these features of supervision and resolution are likely, we believe, to be robust.[45]

To test this we focus on the Covid-19 outbreak in 2020. Our hypothesis is that the repo investors

[44] Such concerns have led regulators to address the reliance on short-term wholesale funding, for example through the Basel III Liquidity Coverage Ratio (LCR). The LCR requires banks to hold a minimum stock of high-quality liquid assets (HQLA) to at least match the expected net cash outflows during a 30-day stress scenario and penalizes the use of unsecured wholesale funding. See BIS (2013).

[45] In unreported results, we replicate the below analysis for other periods during which the market uncertainty rises, and exploit, for example, sudden jumps in the VIX index or temporary dry-ups in the repo market. We again find the ring-fencing bonus to be more pronounced in these time periods. These results are available upon request.

continue to distinguish between the RFB groups and non-RFB groups when they lend cash in short-term money markets during times of financial stress. We thus run a panel fixed effects regression in which we interact the RFB group dummy with the different periods following the Covid-19 shock in the following extension of (5):

$$\begin{aligned} repo_{ijkt} =& \beta_1 ring\text{-}fenced \times March\ 2020 + ... + \beta_8 ring\text{-}fenced \times Aug\ 2020 \\ &+ \beta \times X_{ijtk} + + \alpha \times X_{jt} + dealer_j FE + counterparty_i \times day_t\ FE + \epsilon_{ijkt}. \end{aligned} \tag{10}$$

In estimating equation (10), as in (5), $repo_{ijkt}$ is the interest rate paid by the subsidiary k of the dealer banking group j to receive cash from client i on date t. The treatment variable *ring-fenced* takes a value of 1 if dealer banking group j is subject to ring-fencing and zero otherwise. β_0 thus captures the average difference between the ring-fenced and other dealers. The interaction dummy *March 2020* then captures the ring-fencing bonus to a given Covid month, here March 2020.

In this test therefore RFB-groups are compared with non-RFB groups at particular periods in time. We document the results in column 1 of Table A2. In all our specifications, the differential cost of the repo borrowing remains negative and statistically significant throughout the Covid period, controlling for the deal and gilt collateral characteristics. This reveals that third parties continue to see the RFB group, and the RFB subsidiary as low risk; third parties continue to be willing to lend cash to the RFB group at lower rates. The largest effect on the group is at the start of the lockdown in March 2020. In economic terms, the ring-fencing bonus is statistically significant at the 1% level and 11.76% less relative to the median repo rate.

We also restrict our sample to the period after 2019 and we add a ring-fenced dummy to the specification (10) to isolate the differential rates above the average ring-fencing bonus during the Covid months. We plot our coefficients of interest and their relative confidence intervals at the

95% level of significance in Figure 3, panel A. The dotted red line shows the average ring-fencing bonus during the post-2019 period. The second period on the x-axis corresponds to the first period after the Covid lockdown (April 2020). The figure documents that the reduction in borrowing costs enjoyed by the RFB group expands in magnitude in April 2020 (becomes more negative). This indicates that the additional ring-fencing premium during the Covid months is more than doubled relative to the baseline estimate. We also find that the magnitude of our coefficient of interest on the ring-fenced bank dummy drifts back to our baseline estimate in the months following the initial Covid lockdown. This is perhaps expected as macroeconomic uncertainty declined over this time-frame. All these results are consistent with our leading hypothesis that the third-party investors perceive the ring-fenced banks as safer, and that the ring-fencing bonus becomes quantitatively more substantial in times of market stress. We also find no volume effects throughout the Covid period, as (non) ring-fenced banks follow a similar behaviour (See Figure A.3). This reinforces our finding that ring-fencing has a price rather than a quantity effect.

Second, we attempt to understand whether the time-variation in the ring-fencing bonus during the Covid period hides different dynamics in perceived risk within the RFB and nRFB subsidiaries of the ring-fenced groups. To this end, we split the ring-fence coefficient into two separate dummies to capture the RFB and nRFB subsidiaries of the group. We continue to interact these coefficients with separate monthly indicators that correspond to different months of the Covid-19 shock in 2020 as detailed in (10). We report the result in Column 2 of Table A2. It is apparent from Table A2 that the RFB subsidiary drives the observed behaviour during the period. In all our specifications in Column 1 and 2 which concern the repo transactions, the ring-fencing bonus is negative and statistically significant for the RFB subsidiary in the months leading up to and following the Covid-19 shock.

For the RFB-insulated subsidiary, the effect in the Covid month is remarkably large in economic

terms: it represents a 58% drop relative to the median repo rate relative to the other dealers in the repo market. On the other hand, when we investigate the ring-fencing bonus for the nRFB arm of the ring-fenced bank during Covid, we find that the coefficient of interest on the nRFB does also go down, temporarily initially with some reversal later. This suggests that even the nRFB subsidiary gained some ring-fencing bonus during the period of market stress, and was seen by third parties as (perhaps weakly) less risky than banks unaffected by ring-fencing.

We plot the coefficients in Figure 3. The lower panel of Figure 3 shows that the ring-fenced banks have been able to borrow at lower rates relative to the other banks throughout the Covid outbreak, and that the wedge became even more pronounced during the first month after the lockdown in April. Furthermore, with this analysis, we also show that the safety perception at the banking group level during Covid is largely due to the ring-fenced entity inside the banking group.

These findings suggest that short-term money market investors perceive the ring-fenced banks as a safe heaven, and particularly, during crisis episodes.

One question that arises from this analysis is whether the reduction in the risk perception after the imposition of the fence is concentrated on the repo market, or whether the ring-fenced banks are perceived to be safer in the short-term money markets generally. To test this we extend the analysis in the benchmark specification (5) to other deposits in Table A3 and we run a panel fixed effect specification where the dependent variable is log(total wholesale funding),[46] log(customer deposits), log(bank deposits), and log(other deposits), respectively. The term *ring-fenced* denotes a bank subject to the ring-fencing reform, and $covid_{jt}$ is an indicator variable taking one for 2020, *i.e.*, the first-year of the pandemic outbreak.

In Column 1 of Table A3, we find that the ring-fenced banking groups obtain 15.18% points more total wholesale funding relative to other banks during the first-year of the Covid-19 pandemic,

[46]The total wholesale funding denotes the sum of the customer deposits, bank deposits, other deposits, and any other short-term funding or long-term debt borrowing.

again supporting the view that ring-fenced banks are perceived to be safer. When we look at the differential impact of Covid-19 for different types of deposits, we find that there is no change for customer deposits (Column 2), which is not surprising since the majority of retail deposits are likely to be insured. However, the ring-fenced banks have collected a significantly larger amount of bank deposits (Column 3) and other types of deposits (Column 4) during the Covid outbreak relative to other banks. This suggests that the ring-fencing bonus remains not confined to the repo market but broadly arises due to improved risk perception by participants in a variety of funding markets.

In conclusion we have shown that third parties do perceive ring-fenced groups as safer and so worthy of a low interest rate for them to borrow cash. The nRFB entity within the same group is not perceived to be more risky in general, and in stress times may inherit some of the perceived safety of the RFB subsidiary.

9.2 Is risk-appetite in stress times reduced? Covid-19 Shock

Our next suite of results explores whether the risk appetite of the ring-fenced banks remains reduced even during the same period of extreme market stress. We observed in Section 9.1 that the perception of third parties that RFB groups were safer was preserved, and potentially strengthened, during times of market stress such as presented by Covid. Here we explore if the behaviour of the ring-fenced banking groups justifies this view.

We replicate the analysis in §9.1 and captured as equation (10) on reverse repo transactions at the group level. We report our panel fixed effect regression with the time and ring-fenced-bank interaction dummies in Column 3 of Table A2. We find that the ring-fencing coefficient is significant in the months of March, April and June 2020 which were some of the most fraught in the UK during Covid.

When we separately investigate the differential response of the RFB and nRFB entities to

Covid in Column 4 of Table A2 we uncover that there is a statistically significant reduction in the risk appetite of the RFB subsidiary throughout the Covid period (March –July 2020) which is statistically greater than that pertaining to banks generally at the time. Thus, the ring-fenced subsidiary is more risk-averse particularly during the Covid period. The nRFB entity also becomes more risk-averse in certain months – but to a much lesser extent than the RFB entity (which explains our combined results on the risk aversion at the group level). This again suggests that our results are driven by the RFB subsidiary.

10 Further Robustness Checks

We conclude this study with some further robustness checks.

10.1 Repo robustness and maturity

Our rich data and safe gilt collateral allows us to observe changes in the bank risk through the repo trades. We also have high explanatory power (R^2) for the pricing outcomes in our regressions once we control for the transaction day. We replicate our analysis with a restricted sample on the overnight repo transactions to further insulate our effect from duration risk in Table A5 and Table A6. The results on ring-fencing bonus remain quantitatively similar.[47] We also show in Table A7 that controlling for the transaction hour is insignificant in our pricing regressions. This is not surprising as we observe that repo trades in the UK are widespread during the trading day.

10.2 Pairwise matching, client groups, and general collateral

We replicate our repo analysis with counterparty × dealer and day fixed effects to control for changes in the pairwise matching around the ring-fencing regulation. We find that our ring-fencing

[47] In Table A4, interacting the *ring-fencing* dummy with an indicator that takes one for the overnight repo trades for robustness offers a similar interpretation.

bonus results hold within dealer-client pairs: the same counterparty to the same dealer lends at lower rates after the reform controlling for the transaction day. Thus, the ring-fencing bonus is not driven by matching, *i.e.* the dealers switching to different clients to obtain more favourable rates. We report the results in the Column 1 and 2 of A8.

In further robustness checks, we drop pension funds, MMFs and in Column 3. We see the ring-fencing bonus to be quantitatively similar across different types of clients.

In Column 4, we run the alternative specification where we separately add $ring\text{-}fencing_{jt}$ and RFB_{ijt} to the baseline regressions. The results again suggest that the more favourable rates under ring-fencing are particularly driven by the ring-fenced subsidiary.

In Column 5, we control for the presence of general collateral in the transaction (collateral without individual ISIN). This type of collateral represents only 5% of the repo market during the entire sample period (that is persistent). We add an indicator special that takes one if the collateral is not classified as general. We see that while special collateral is associated with lower rates in the repo transactions, it has very little effect on our coefficient of interest.

10.3 Different time windows

We also check the robustness to a variety of alternative specifications with different time windows. Thus, we compare for the same counterparty, the rates given to the ring-fenced dealers relative to other dealers across different time windows. We use counterparty×month and counterparty×year fixed effects. We report the results in Table A9 and find that our baseline estimates remain similar. Our results also remains robust to taking the natural logarithm of the dependent variable (Column 3) and accounting for the period-ends (Column 4).

11 Conclusion

Following the Great Financial Crisis, many regulators have searched for more radical approaches than capital and liquidity requirements to increase the resilience of the financial system and to mitigate the too-big-to-fail problem. How to best restructure the banking system remains an open question for both economists and regulators. One prominent approach has been to impose structural reforms that require banking groups to ring-fence some of their banking operations. Empirical research is largely silent on the impact of ring-fencing on the risk perception and risk appetite of the affected banking group and its separate subsidiaries. Our work offers empirical evidence towards filling this gap.

Legally subdividing a bank and restricting activities in some of its constituent parts has been enacted in the UK, considered in the EU (via the Liikanen report), and existed in a mild form in the US even prior to the Great Financial Crisis through the restrictions mandated by the Bank Holding Company Act 1956 (Gleeson, 2015). In this paper we focus on the UK ring-fencing reform (Vickers, 2011) that splits banks into two legally distinct subsidiaries: RFB and nRFB with domestic retail banking only permitted in the RFB. Such ring-fencing can, the authorities argue, improve supervision and help in resolution. We empirically study the impact of this mandatory change in governance on interest rates which banks are charged by informed counterparties and at which they lend. We argue that the former captures third party views of the riskiness of RFB, while the latter captures the bank's risk appetite.

Our regulatory set-up imposes an exogenous threshold that we exploit for identification with our high-frequency bilateral prices. We uncover the existence of a ring-fencing bonus, *i.e.* evidence that ring-fencing is perceived by third parties as insulating the RFB subsidiary from risk. Third parties are therefore willing to lend cash to these entities at lower rates than otherwise. We find that there is no significant impact on the perceived riskiness of the nRFB. The RFB, we find,

remains as committed to the repo market, but it provides liquidity at a higher price. We further document that the ring-fenced banks reduce their risk-taking after the fence and build up more deposits during times of stress. The ring-fencing bonus is, we find, durable; affected banks were more resilient to the Covid-19 outbreak relative to other banks. In effect, therefore, ring fencing can create a safe-haven in the banking network.

We are able to rule out cost and supply effects as alternative explanations for our results on the liquidity provision. There is no evidence that ring-fenced banks reduce their supply of liquidity into the market, making a supply-side explanation unlikely. The costs of providing repo to a bank are affected by its own cost of capital, which one might fear is affected by ring-fencing. We note that not all repo transactions expand the balance sheet and so plausibly alter the cost of capital via the leverage ratio limit – nettable ones do not. Yet we show that the ring-fencing bonus applies irrespectively of the nettable status of the repo.

We therefore conclude that third parties see ring fenced groups as safer and that this safety is predominantly enjoyed by the ring fenced subsidiary. The non-ring fenced subsidiary is not however exposed to higher costs of liquidity, or seen as less safe, to any economically meaningful extent.

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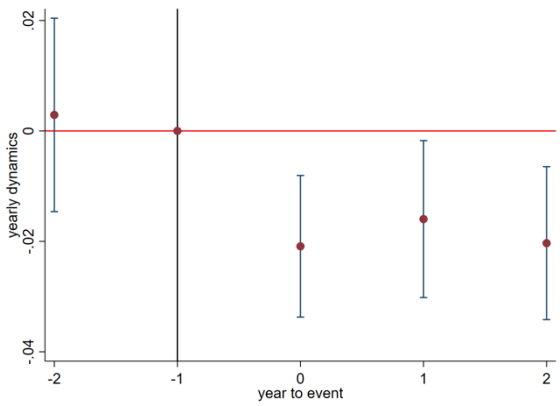
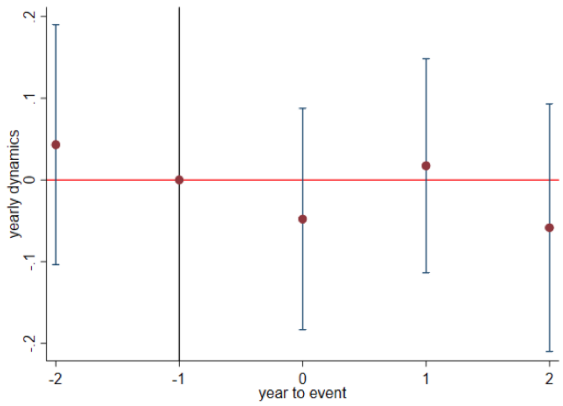
12 Main Figures and Tables

Figure 1. Rate and volume dynamics pre- and post-implementation



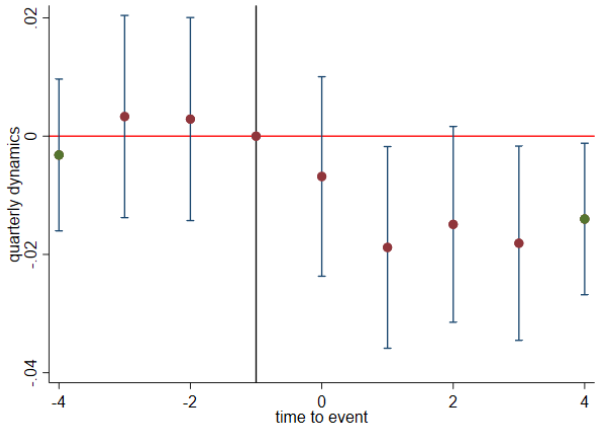
Graph A – coefficients and CI based on repo rate as dep. var.



Graph B – coefficients and CI based on volumes as dep. var.

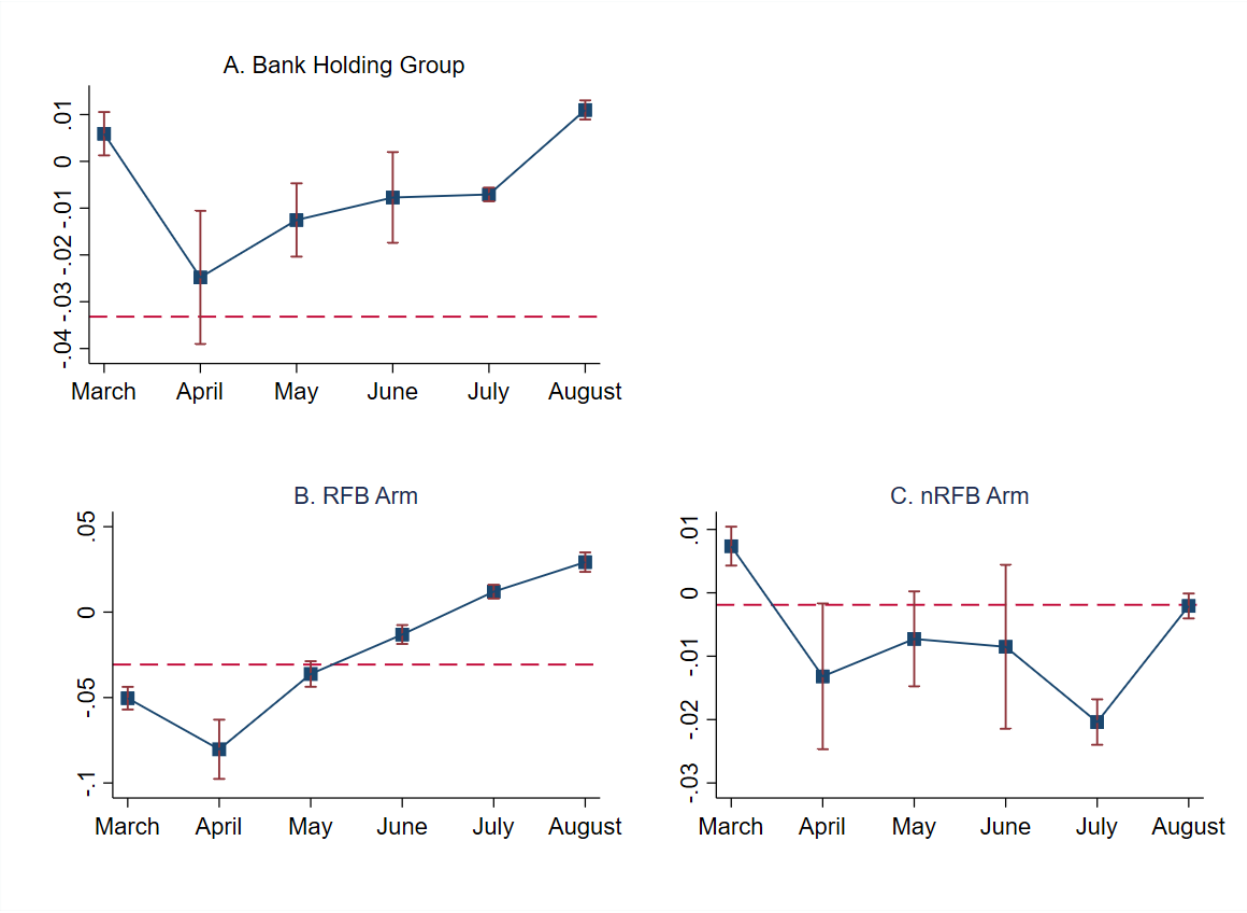
NOTES: Graph A displays the coefficients and confidence intervals estimated for the baseline specification (5) adjusted to include lead and lag dummy variables interacted with RFB group status in a dynamic Granger test for pre-trends. While Graph A uses the repo rate as the dependent variable, Graph B uses the natural log of transaction volume as dependent variable. On the x-axis, 0 refers to 2019 as implementation year of ring-fencing, running from 2017 (-2) to 2021 (2). Both sets of estimates control for dealer and counterparty fixed effects.

Figure 2. The ring-fencing bonus



NOTES: The figure displays the coefficients and confidence intervals estimated for the baseline specification (5) adjusted to include lead and lag dummy variables interacted with RFB group status in a dynamic Granger test for pre-trends. The repo rate is the dependent variable. On the x-axis, 0 refers to 2019 as implementation quarter of ring-fencing, running from 2019 (-4) to 2021 (4). Both sets of estimates control for dealer and counterparty fixed effects.

Figure 3. The ring-fencing bonus during Covid-19



NOTES: We run our baseline bank panel FE specification on the repo transactions by restricting our data to the period after 2019. The graph presents the coefficients and confidence intervals on the interaction between different months of the coronavirus period in 2020 with (i) panel A- ring-fenced banking holding group (BHG); (ii) panel B - the RFB arm of the ring-fenced banking group; (iii) panel C- the nRFB arm of the ring-fenced banking group. Estimates from (ii) and (iii) come from a panel specification of the RFB and nRFB dummies interacted with the different month periods during the coronavirus shock. The dotted red line is the average ring-fencing bonus during the time period after 2019.

Table 1. Counterparty and Dealer Trades in the Repo Market

PANEL A

Repo Transactions		Reverse Repo Transactions	
Number of dealer groups	26	Number of dealer groups	27
Number of counterparties	3235	Number of counterparties	4996
Number of counterparty groups	726	Number of counterparty groups	820
Number of dealer-counterparty pairs	2771	Number of dealer-counterparty pairs	3261

PANEL B

Repo Transactions		Reverse Repo Transactions	
Share of dealers per counterparty (daily average)	44%	Share of dealers per counterparty (daily average)	43%
Share of dealers per counterparty (sample mean)	65%	Share of dealers per counterparty (sample mean)	60%
Number of trades per counterparty (yearly average)	214711	Number of trades per counterparty (yearly average)	215648
Number of trades per counterparty (daily average)	935	Number of trades per counterparty (daily average)	948

NOTES: This table reports summary statistics on the counterparty-dealer trades and pairs in the repo market during the study period. Panel A reports the number of dealers, counterparties, and dealer-counterparty pairs. Panel B presents the average number of dealers that trade with each counterparty and the number of trades completed on average by each counterparty during the sample period.

Table 2. Repo Trade Characteristics

PANEL A	**Counterparty Types**		
Repo Transactions	Percent	Reverse Repo Transactions	Percent
Bank	2	Bank	1.41
Sovereigns	0.31	Sovereigns	0.67
Funds and MMFs	16.21	Fund and MMFs	14.65
Insurers and Pension funds	2.55	Insurer	2.05
Non-Financials	1.1	Non-Financials	1.24
Other Financial	78.02	Other Financial	79.98

PANEL B	**Trade Maturity**		
Repo Transactions	Percent	Reverse Repo Transactions	Percent
Overnight	86.68	Overnight	84.39
1 Day to 1 Month	12.07	One Day to 1 Month	12.27
3 Months to 1 Year	1.24	3 Months to 1 Year	3.32

NOTES: This table presents the counterparty types and the trade maturities in the (reverse) repo transactions.

Table 3. Summary Statistics - transactions

PANEL A

Repo Transactions	1%	25%	50%	Mean	75%	99%	Standard Deviation
Amount	1054100	1.00E+07	2.70E+07	5.36E+07	5.75E+07	4.16E+08	1.03E+08
log(Amount)	13.8682	16.1218	17.1109	16.9693	17.8677	16.9693	1.3592
Deal Rate	-0.15	0.05	0.25	0.3383	0.7	0.78	0.3085
Collateral Haircut	-3.6269	0	0	0.8625	0	99	10.7678
Collateral Maturity (years)	0.5452	5.1288	9.7014	15.1548	23.5206	50.8301	12.8415

PANEL B

Reverse Repo Transactions	1 %	25 %	50 %	Mean	75 %	99 %	Standard Deviation
Amount	1061400	9320000	2.48E+07	4.09E+07	5.01E+07	2.63E+08	5.98E+07
log(Amount)	13.8751	16.0477	17.0275	16.8458	17.7285	19.3894	1.2591
Deal Rate	-0.15	0.06	0.25	0.3463	0.71	0.85	0.3351
Collateral Haircut	-24.54	0	0	-67.8699	0	2	75048.52
Collateral Maturity (years)	0.5151	5.1425	9.6932	15.0783	23.1425	50.8493	12.7959

NOTES: We report the various percentiles of the mean, standard deviation, and various percentiles of our key variables of interest separately for the (reverse) repo transactions in Panel A and B, respectively.

Table 4. Pre-Treatment Covariates

Full Sample	**Treated**	**Control**
	(1)	(2)
log(deposits)	20.1145	19.7779
log(equity)	2.0386	1.9902
log(assets)	20.8299	20.4159
ROA	0.3395	0.4447
Cost to income	66.7817	66.1922
Liquidity Coverage Ratio	136.9673	136.8957
Tier1 Cap Ratio	16.4037	15.4743
Price-to-Book	90.9258	112.8208
Propensity-score-matched sample	**Treated**	**Control**
	(1)	(2)
log(deposits)	20.1145	19.6978
log(equity)	2.0386	1.8968
log(assets)	20.8299	20.6836
ROA	0.3395	0.2986
Cost to income	66.7817	77.3865
Liquidity Coverage Ratio	136.9673	152.2295
Tier 1 Cap Ratio	16.4037	16.3542
Price-to-Book	90.9258	89.4009

NOTES: This table reports the pre-treatment covariates for the ring-fenced and other bank dealers. Panel A reports these characteristics for the full sample of the bank dealers in the UK gilt market. Panel B reports the pre-treatment characteristics for a matched control group among the UK-sterling deposit taking dealers using the nearest-neighbor matching with the probit method.

Table 5. Repo Transactions and Ring-Fencing - group level

Repo Rate	(1)	(2)	(3)	(4)	(5)
ring-fencing$_{jt}$	-0.00885***	-0.00495***	-0.00688**	-0.00490**	-0.00881***
	(0.00118)	(0.00127)	(0.00315)	(0.00236)	(0.00271)
log(assets)			0.03487**	0.02871**	0.00310
			(0.01538)	(0.01427)	(0.01321)
leverage ratio			0.00930***	0.01135***	0.00264***
			(0.00143)	(0.00198)	(0.00063)
ROA			0.00013	-0.00020	0.00169***
			(0.00067)	(0.00076)	(0.00051)
liquidity coverage ratio			-0.00022*	-0.00026**	-0.00032***
			(0.00013)	(0.00012)	(0.00009)
loans/deposits			0.00035	0.00022	0.00034*
			(0.00034)	(0.00031)	(0.00019)
haircut				-0.00022***	-0.00011*
				(0.00006)	(0.00006)
log(amount)				0.00001	0.00059*
				(0.00055)	(0.00032)
log(maturity)					0.01661***
					(0.00146)
high price volatility					0.01552***
					(0.00126)
N	2377818	2229620	837642	837636	578211
R^2	0.95	0.96	0.95	0.95	0.96
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	No	Yes	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Credit rating FE	No	No	Yes	Yes	Yes
Dealer Controls	No	No	No	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the repo rates at the level of the banking groups. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table 6. Repo Transactions and Ring-Fencing - subsidiaries

Repo Rate	(1)	(2)	(3)	(4)	(5)
RFB_{jkt}	-0.02509***	-0.02168***	-0.02604***	-0.02377***	-0.02944***
	(0.00089)	(0.00149)	(0.00348)	(0.00261)	(0.00336)
$nRFB_{jkt}$	-0.00433***	-0.00138*	-0.00139	-0.00041	-0.00426*
	(0.00071)	(0.00080)	(0.00258)	(0.00211)	(0.00222)
log(assets)			0.04480**	0.04037**	0.01472
			(0.01769)	(0.01642)	(0.01622)
leverage ratio			0.01478***	0.01580***	0.00723***
			(0.00214)	(0.00246)	(0.00136)
ROA			-0.00129*	-0.00143*	0.00051
			(0.00073)	(0.00078)	(0.00055)
liquidity coverage ratio			-0.00026**	-0.00028**	-0.00035***
			(0.00013)	(0.00012)	(0.00009)
loans/deposits			0.00019	0.00012	0.00025
			(0.00030)	(0.00029)	(0.00017)
haircut				-0.00014***	-0.00004
				(0.00005)	(0.00005)
log(amount)				-0.00002	0.00055*
				(0.00053)	(0.00031)
log(maturity)					0.01616***
					(0.00159)
high price volatility					0.01548***
					(0.00123)
N	2377818	2229620	837642	837636	578211
R^2	0.95	0.96	0.95	0.95	0.96
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	No	Yes	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Credit rating FE	No	No	Yes	Yes	Yes
Dealer Controls	No	No	No	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the repo rates by RFB and nRFB subsidiaries, separately. The variable RFB_{jkt} ($nRFB_{jkt}$) is one if the subsidiary k of the dealer banking group j is (not) ring-fenced at time t when the Court approves ring-fencing for the dealer banking group j, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table 7. Reverse repo Transactions and Ring-Fencing - group level

Reverse Repo Rate	(1)	(2)	(3)	(4)	(5)
ring-fencing$_{jt}$	0.01428***	0.01178**	0.01834**	0.01829**	0.01374**
	(0.00502)	(0.00433)	(0.00751)	(0.00784)	(0.00520)
log(assets)			-0.01466	-0.01399	0.00373
			(0.05106)	(0.05044)	(0.05148)
leverage ratio			0.00353	0.00350	0.00787
			(0.00616)	(0.00625)	(0.00626)
ROA			-0.00050	-0.00052	-0.00141
			(0.00130)	(0.00133)	(0.00137)
liquidity coverage ratio			-0.00017	-0.00016**	-0.00007
			(0.00010)	(0.00007)	(0.00010)
loans/deposits			0.00035	0.00036	0.00026
			(0.00048)	(0.00046)	(0.00039)
haircut			0.00001	-0.00016*	
			(0.00013)	(0.00008)	
log(amount)				-0.00116	0.00047
				(0.00133)	(0.00113)
log(maturity)					0.01354***
					(0.00157)
high price volatility					0.02044***
					(0.00304)
N	2378122	2234889	790148	790136	544378
R^2	0.94	0.95	0.94	0.94	0.95
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Credit rating FE	No	Yes	Yes	Yes	Yes
Dealer Controls	No	No	Yes	Yes	Yes
Deal Controls	No	No	No	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the reverse repo rates at the level of the banking groups. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table 8. Reverse repo Transactions and Ring-Fencing - subsidiaries

Reverse Repo Rate	(1)	(2)	(3)	(4)	(5)
RFB_{jkt}	0.02437***	0.01933**	0.02279*	0.02283*	0.02015*
	(0.00379)	(0.00751)	(0.01194)	(0.01188)	(0.00934)
$nRFB_{jkt}$	0.01327**	0.01120**	0.01797**	0.01790**	0.01325**
	(0.00504)	(0.00433)	(0.00717)	(0.00754)	(0.00502)
log(assets)			-0.01532	-0.01471	0.00349
			(0.05141)	(0.05080)	(0.05159)
leverage ratio			0.00329	0.00324	0.00753
			(0.00606)	(0.00616)	(0.00615)
ROA			-0.00058	-0.00061	-0.00150
			(0.00132)	(0.00135)	(0.00143)
liquidity coverage ratio			-0.00016	-0.00015**	-0.00006
			(0.00010)	(0.00007)	(0.00010)
loans/deposits			0.00038	0.00040	0.00031
			(0.00050)	(0.00049)	(0.00042)
haircut				0.00001	-0.00016*
				(0.00013)	(0.00008)
log(amount)				-0.00117	0.00047
				(0.00133)	(0.00113)
log(maturity)					0.01353***
					(0.00156)
high price volatility					0.02049***
					(0.00306)
N	2378122	2234889	790148	790136	544378
R^2	0.94	0.95	0.94	0.94	0.95
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Credit rating FE	No	Yes	Yes	Yes	Yes
Dealer Controls	No	No	Yes	Yes	Yes
Deal Controls	No	No	No	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the reverse repo rates by RFB and nRFB subsidiaries, separately. The variable RFB_{jkt} ($nRFB_{jkt}$) is one if the subsidiary k of the dealer banking group j is (not) ring-fenced at time t when the Court approves ring-fencing for the dealer banking group j, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table 9. Mechanism: Is The Risk-Fencing Bonus Warranted or does it reflect Too-Vital-to-Fail?

Repo Rate	(1)	(2)	(3)	(4)
ring-fencing$_{jt}$	-0.00200	-0.00062	-0.00133	0.00001
	(0.00276)	(0.00181)	(0.00302)	(0.00209)
log(assets)	-0.01064	-0.01312	-0.00905	-0.01107
	(0.02182)	(0.02071)	(0.02137)	(0.02032)
leverage ratio	0.01076***	0.01110***	0.01009***	0.01038***
	(0.00284)	(0.00296)	(0.00271)	(0.00282)
ROA	0.00153*	0.00158*	0.00171**	0.00177**
	(0.00088)	(0.00084)	(0.00086)	(0.00081)
liquidity coverage ratio	-0.00004	-0.00008	-0.00006	-0.00010
	(0.00015)	(0.00013)	(0.00015)	(0.00013)
loans/deposits	-0.00002	-0.00006	0.00003	-0.00001
	(0.00036)	(0.00033)	(0.00034)	(0.00031)
haircut		-0.00013		-0.00012
		(0.00009)		(0.00008)
log(amount)		-0.00040		-0.00041
		(0.00050)		(0.00050)
distance-to-default	0.00154***	0.00159***		
	(0.00008)	(0.00011)		
z-score			-0.00004***	-0.00005***
			(0.00001)	(0.00001)
N	703386	703380	703386	703380
R^2	0.95	0.95	0.95	0.95
Counterparty × Day FE	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes
Dealer FE	Yes	Yes	Yes	Yes
Credit rating FE	Yes	Yes	Yes	Yes
Dealer Controls	Yes	Yes	Yes	Yes
Deal Controls	No	Yes	No	Yes

NOTES: This table reports the impact of ring-fencing on the repo rates at the level of the banking groups, controlling for market-based measures of risk such as the Z-score and distance-to-default. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table 10. Reverse repo volumes and Ring-Fencing

log(Reverse Repo Amount)	(1)	(2)	(3)	(4)	(5)
ring-fencing$_{jt}$	-0.00010	0.14879	0.00589	-0.00269	0.01074
	(0.06378)	(0.08734)	(0.07053)	(0.07110)	(0.07183)
log(assets)			0.72295**	0.70019**	0.45022
			(0.30397)	(0.29466)	(0.28893)
leverage ratio			0.01372	0.00741	0.06830
			(0.06510)	(0.06720)	(0.06029)
ROA			-0.02681	-0.02607	-0.03373
			(0.02058)	(0.02082)	(0.02343)
liquidity coverage ratio			0.00356**	0.00381**	0.00425**
			(0.00144)	(0.00146)	(0.00196)
loans/deposits			0.00706*	0.00732*	0.00386
			(0.00382)	(0.00387)	(0.00393)
haircut				0.00068	0.00068
				(0.00100)	(0.00147)
log(maturity)					-0.06314
					(0.03770)
high price volatility					-0.12924*
					(0.07037)
N	2378122	2234889	790148	790136	544378
R^2	0.12	0.15	0.16	0.16	0.17
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Credit rating FE	No	Yes	Yes	Yes	Yes
Dealer Controls	No	No	Yes	Yes	Yes
Deal Controls	No	No	No	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the reverse repo volumes at the banking group level. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table 11. Repo - Firm Heterogeneity

Repo Rate	Dealer Bank Characteristics			Counterparty Characteristics	
	(1)	(2)	(3)	(4)	(5)
ring-fencing$_{jt}$	0.01955***	0.02178***	0.00832	0.01109**	0.01823**
	(0.00605)	(0.00649)	(0.00730)	-0.00511	(0.00786)
ring-fencing$_{jt}$ × *Illiquid Dealer*	-0.00796				
	(0.00894)				
ring-fencing$_{jt}$ × *Small Dealer*		-0.00990			
		(0.00927)			
ring-fencing$_{jt}$ × *Weakly Capitalized Dealer*			0.01381***		
			(0.00393)		
ring-fencing$_{jt}$ × *Small*				0.06696***	
				(0.00750)	
ring-fencing$_{jt}$ × *Counterparty with New Relationship*					0.00462
					(0.00707)
N	797401	790136	790136	790136	790136
R^2	0.94	0.94	0.94	0.94	0.94
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes	Yes
Dealer FE	Yes	Yes	Yes	Yes	Yes
Credit rating FE	Yes	Yes	Yes	Yes	Yes
Dealer Controls	Yes	Yes	Yes	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes	Yes

NOTES: This table reports the heterogenous impact of ring-fencing on the deal rates in the reverse repo transactions by both dealer and counterparty characteristics. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. Columns 1-3 present the heterogeneous impact of ring-fencing by bank dealer characteristics and Columns 4 & 5 report heteogeneity by counterparty characteristics. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Online Appendix

A Further Tables and Figures

Figure A.1. Share of repo trades in the RFBs

This figure presents the share of the total number of transactions by the RFB entities of the ring-fenced banks (%) after the ring-fencing reform.

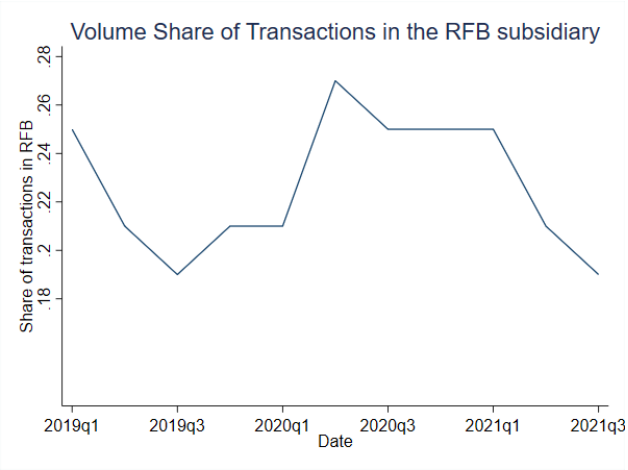


Figure A.2. Repo volumes

This figure reports the total volume of repo trading for ring-fenced and other bank dealers separately for the period 2016-2021.

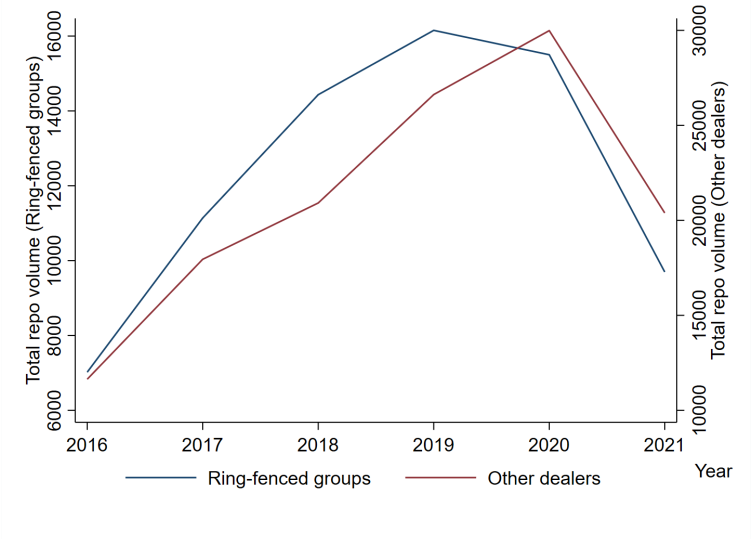


Figure A.3. Repo volumes during Covid

This figure reports the total volume of repo trading for ring-fenced and other bank dealers separately for the Covid period in 2020.

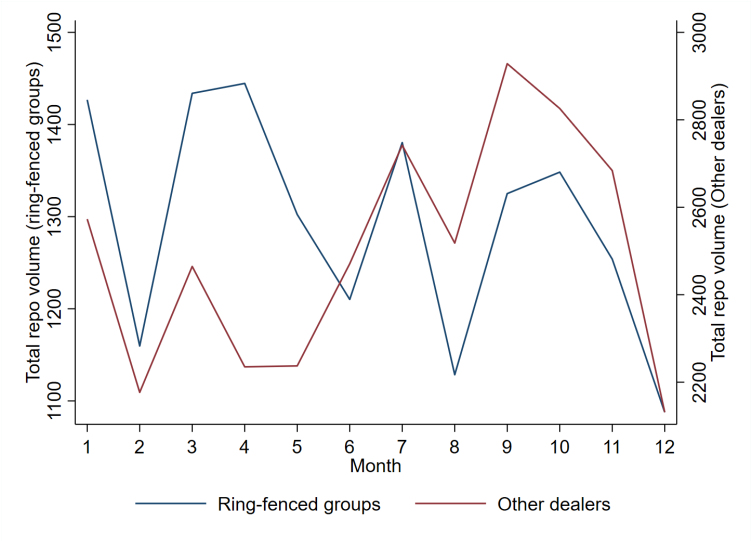


Table A1. Robustness: Propensity-score matching, restricted sample, and first-differences

Rate	Propensity-score-matched sample	Restricted sample to the year of 2018	First-differences
	(1)	(2)	(3)
	-0.01936***	-0.01061***	-0.02414***
	(0.00106)	(0.00251)	(0.00803)
N	76586	422300	975
R^2	0.86	0.81	0.39

NOTES: This table reports the robustness tests for the baseline specification that tests the impact of ring-fencing on the repo rates. Column (1) uses the propensity-score matched sample, and Column (2) restricts the sample period to 2018. Column (3), on the other hand, uses first-differences by averaging the counterparty-dealer rates both before and after ring-fencing. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table A2. Covid Period: Ring-fencing groups and Market Stress

Rate	Repo		Reverse Repo	
	(1)	(2)	(3)	(4)
ring-fenced × *March*	-0.02944***		0.05512***	
	(0.00887)		(0.01356)	
ring-fenced × *April*	-0.00393		0.05949**	
	(0.01291)		(0.02464)	
ring-fenced × *May*	-0.0148***		0.00981	
	(0.00535)		(0.0179)	
ring-fenced × *June*	-0.01276**		0.04956**	
	(0.0057)		(0.02219)	
ring-fenced × *July*	-0.01282***		0.03695*	
	(0.00224)		(0.01824)	
ring-fenced × *August*	-0.01239***		0.01965	
	(0.00266)		(0.01567)	
RFB × *March*		-0.14515***		0.08322***
		(0.03319)		(0.01285)
RFB × *April*		-0.00892		0.12766***
		(0.00599)		(0.00606)
RFB × *May*		-0.02217***		0.09999***
		(0.0076)		(0.0073)
RFB × *June*		-0.02412***		0.10714***
		(0.00764)		(0.00549)
RFB × *July*		-0.0362***		0.08925***
		(0.00911)		(0.00773)
RFB × *August*		-0.01607**		0.07105***
		(0.00747)		(0.01865)
nRFB × *March*		-0.02973**		0.01917
		(0.01183)		(0.01139)
nRFB × *April*		-0.00425		0.03488**
		(0.0284)		(0.01617)
nRFB × *May*		-0.01257		-0.00019
		(0.01488)		(0.00998)
nRFB × *June*		-0.00773		0.02618**
		(0.01557)		(0.00982)
nRFB × *July*		(0.0076)		(0.0122)
		(0.00182)		(0.00817)
nRFB × *August*		-0.0111**		0.01117
		(0.00477)		(0.00927)
N	2229620	2229620	2234889	2234889
R^2	0.96	0.96	0.95	0.95
Counterparty × Day FE	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes
Dealer FE	Yes	Yes	Yes	Yes
Credit rating FE	Yes	Yes	Yes	Yes
Dealer Controls	Yes	Yes	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes

NOTES: This table reports the response of repo rates to the Covid market stress. Column 1-2 (3-4) run a panel specification on (reverse) repo transactions where the ring-fenced, RFB, and nRFB dummies are interacted with dummy variables corresponding to months before and after the UK Covid lockdown. The bottom of the table provides information about fixed effects. Standard errors correct for clustering at the lender-level and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table A3. Covid period: Ring-fencing and Wholesale/Deposit Funding

	log(Wholesale Funding)	log (Customer Deposits)	log(Bank Deposits)	log(Other Deposits)
$covid_{jt}$	-2.0794***	-0.1598***	-0.0314	0.1239
	(0.0796)	(0.0196)	(0.1006)	(0.0930)
ring-fenced $\times$ $covid_{jt}$	0.1518**	-0.0529	0.3965***	0.5164***
	(0.0673)	(0.0381)	(0.0808)	(0.0704)
N	497643	377587	192457	206153
R^2	0.9017	0.9908	0.9310	0.9325

NOTES: This table reports the differential response of the wholesale funding and deposits of the ring-fenced banks to the Covid market stress during 2020, *i.e.*, the first year of the Covid outbreak. *ring-fenced* is one if the dealer banking group j is subject to ring-fencing and zero otherwise. $covid_{jt}$ takes one after the first Covid lockdown and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table A4. Repo Robustness - Nettable trades

Repo Rate	(1)	(2)	(3)	(4)
	Nettable		Overnight	
ring-fencing$_{jt}$	-0.01824***	-0.00662**	-0.01576***	-0.00675***
	(0.00292)	(0.00315)	(0.00161)	(0.00059)
ring-fencing$_{jt}$ × *Overnight*			-0.00903***	-0.00622***
			(0.00054)	(0.00045)
bank rate		0.26423***		0.23049***
		(0.00711)		(0.04611)
log(assets)		0.04035***		0.05175***
		(0.01091)		(0.01498)
leverage ratio		0.00966***		0.01120***
		(0.00143)		(0.00215)
ROA		0.00008		-0.00016
		(0.00074)		(0.00049)
liquidity coverage ratio		-0.00021*		-0.00013*
		(0.00012)		(0.00008)
loans/deposits		0.00040		0.00054***
		(0.00032)		(0.00019)
N	1449627	793976	1342793	738328
R^2	0.95	0.94	0.96	0.95
Counterparty × Day FE	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes
Dealer FE	Yes	Yes	Yes	Yes
Credit rating FE	Yes	Yes	Yes	Yes
Dealer Controls	No	Yes	No	Yes
Deal Controls	Yes	Yes	Yes	Yes

NOTES: This table reports the heterogenous impact of ring-fencing on the repo rates at the level of the banking groups for different levels of maturity and nettability. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. The bottom of the table provides information about fixed-effects, and the level of clustering. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table A5. Repo Robustness - Overnight transactions (group level)

Repo Rate	(1)	(2)	(3)	(4)	(5)
ring-fencing$_{jt}$	-0.00946***	-0.01960***	-0.00888***	-0.00653***	-0.00987***
	(0.00075)	(0.00127)	(0.00022)	(0.00045)	-0.0007
log(assets)			0.04319***	0.03704***	0.01319
			(0.01333)	(0.01281)	(0.00877)
leverage ratio			0.00979***	0.01201***	0.00359***
			(0.00186)	(0.00221)	(0.00055)
ROA			-0.00051	-0.00084	0.00116***
			(0.00050)	(0.00056)	(0.00031)
liquidity coverage ratio			-0.00014*	-0.00018***	-0.00026***
			(0.00007)	(0.00007)	(0.00006)
loans/deposits			0.00054***	0.00041**	0.00048***
			(0.00020)	(0.00018)	(0.00010)
haircut				-0.00024***	-0.00013***
				(0.00003)	(0.00003)
log(amount)				-0.00005	0.00050***
				(0.00015)	(0.00005)
log(maturity)					0.01478***
					(0.00030)
high price volatility					0.01520***
					(0.00144)
N	2064032	1332151	733215	733209	500107
R^2	0.95	0.96	0.95	0.95	0.96
Counterparty × Dealer FE	Yes	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	No	Yes	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Credit rating FE	No	No	Yes	Yes	Yes
Dealer Controls	No	No	No	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the repo rates at the level of the banking groups. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table A6. Repo Robustness - Overnight transactions (subsidiaries)

Repo Rate	(1)	(2)	(3)	(4)	(5)
RFB_{jkt}	-0.02509***	-0.02168***	-0.02604***	-0.02377***	-0.02944***
	(0.00089)	(0.00149)	(0.00348)	(0.00261)	(0.00336)
$nRFB_{jkt}$	-0.00433***	-0.00138*	-0.00139	-0.00041	-0.00426*
	(0.00071)	(0.00080)	(0.00258)	(0.00211)	(0.00222)
log(assets)			0.04480**	0.04037**	0.01472
			(0.01769)	(0.01642)	(0.01622)
leverage ratio			0.01478***	0.01580***	0.00723***
			(0.00214)	(0.00246)	(0.00136)
ROA			-0.00129*	-0.00143*	0.00051
			(0.00073)	(0.00078)	(0.00055)
liquidity coverage ratio			-0.00026**	-0.00028**	-0.00035***
			(0.00013)	(0.00012)	(0.00009)
loans/deposits			0.00019	0.00012	0.00025
			(0.00030)	(0.00029)	(0.00017)
haircut				-0.00014***	-0.00004
				(0.00005)	(0.00005)
log(amount)				-0.00002	0.00055*
				(0.00053)	(0.00031)
log(maturity)					0.01616***
					(0.00159)
high price volatility					0.01548***
					(0.00123)
N	2377818	2229620	837642	837636	578211
R^2	0.95	0.96	0.95	0.95	0.96
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	No	Yes	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Credit rating FE	No	No	Yes	Yes	Yes
Dealer Controls	No	No	No	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the repo rates by RFB and nRFB subsidiaries, separately. The variable RFB_{jkt} ($nRFB_{jkt}$) is one if the subsidiary k of the dealer banking group j is (not) ring-fenced at time t when the Court approves ring-fencing for the dealer banking group j, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table A7. Repo Robustness - Intraday

Repo Rate	(1)	(2)	(3)	(4)	(5)
ring-fencing$_{jt}$	-0.009***	-0.01805***	-0.00708***	-0.00509***	-0.00911***
	(0.00098)	(0.00310)	(0.00252)	(0.00173)	(0.00183)
hour$_{jt}$	-0.00014	-0.00008	-0.00030	-0.00026	-0.00037
	(0.00025)	(0.00046)	(0.00054)	(0.00055)	(0.00065)
log(assets)			0.03613***	0.02986**	0.00500
			(0.01361)	(0.01227)	(0.01056)
leverage ratio			0.00914***	0.01118***	0.00250***
			(0.00170)	(0.00233)	(0.00082)
ROA			0.00021	-0.00013	0.00180***
			(0.00079)	(0.00090)	(0.00064)
liquidity coverage ratio			-0.00021*	**-0.00025	-0.00030***
			(0.00011)	(0.00010)	(0.00007)
loans/deposits			0.00036	0.00023	0.00035**
			(0.00033)	(0.00029)	(0.00016)
haircut				***-0.00022	-0.00011
				(0.00006)	(0.00007)
log(amount)				0.00003	0.00061**
				(0.00052)	(0.00029)
log(maturity)					0.01657***
					(0.00143)
high price volatility					0.01551***
					(0.00129)
N	2377818	1521701	837642	837636	578211
R^2	0.95	0.95	0.95	0.95	0.96
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	No	Yes	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Credit rating FE	No	No	Yes	Yes	Yes
Dealer Controls	No	No	No	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the repo rates at the level of the banking groups controlling for the intraday hour of the transaction. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. *hour*$_{ijt}$ refers to the hour of the transaction. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table A8. Repo Robustness - Alternative specifications

Repo Rate	(1)	(2)	(3)	(4)	(5)
ring-fencing$_{jt}$	-0.00972**		-0.00873***	-0.00531**	-0.0088***
	(0.0042)		(0.00286)	(0.00228)	(0.00269)
RFB_{jkt}		-0.02556***		-0.02449***	
		(0.00245)		(0.0019)	
$nRFB_{jkt}$		-0.00024			
		(0.00219)			
log(assets)	0.00859	0.01606	0.01438***	0.0018	0.00346
	(0.01293)	(0.01487)	(0.00352)	(0.01482)	(0.013)
leverage ratio	0.00084	0.00365	0.00215**	0.0041***	0.00268***
	(0.00296)	(0.00454)	(0.00105)	(0.00112)	(0.00061)
ROA	0.00339*	0.00228	0.00158***	0.00065	0.0017***
	(0.00177)	(0.00191)	(0.00039)	(0.00055)	(0.0005)
liquidity coverage ratio	-0.0002***	-0.00023***	-0.00026***	-0.00031***	-0.00032***
	(0.00006)	(0.00005)	(0.00003)	(0.0001)	(0.0001)
loans/deposits	-0.00001	0.00006	0.00035*	0.00039**	0.00035*
	(0.00025)	(0.00026)	(0.00018)	(0.00019)	(0.00019)
haircut	-0.00012**	-0.00004	-0.00016***	-0.00003	-0.00011*
	(0.00006)	(0.00005)	(0.00000)	(0.00005)	(0.00006)
log(maturity)	0.017***	0.0165***	0.00034	0.00053*	0.01661***
	(0.00161)	(0.00172)	(0.00058)	(0.0003)	(0.00146)
log(amount)	0.00046	0.00038	0.01662***	0.01615***	0.00056
	(0.00038)	(0.00037)	(0.00151)	(0.0016)	(0.00035)
high price volatility	0.01586***	0.0158***	0.01582***	0.01553***	0.01549***
	(0.00114)	(0.00112)	(0.00112)	(0.00126)	-0.00127
special					-0.01133***
					(0.00054)
N	578073	578073	559806	578211	578211
R^2	0.95	0.95	0.96	0.96	0.96
Counterparty × Day FE	No	No	Yes	Yes	Yes
Counterparty × Dealer FE	Yes	Yes	No	No	No
Day FE	Yes	Yes	No	No	No
Counterparty-Subsidiary Type FE	No	Yes	Yes	Yes	Yes
Dealer FE	No	No	Yes	Yes	Yes
Credit rating FE	No	No	Yes	Yes	Yes
Dealer Controls	No	No	No	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the repo rates with alternative specifications. The variable RFB_{jkt} ($nRFB_{jkt}$) is one if the subsidiary k of the dealer banking group j is (not) ring-fenced at time t when the Court approves ring-fencing for the dealer banking group j, and zero otherwise. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively. Column specifications are described in Section 10.2.

Table A9. Repo Robustness - Alternative specifications

PANEL A	(1)	(2)	(3)	(4)
Repo Rate	Monthly	Yearly	log(Deal Rate)	Quarter-ends
ring-fencing$_{jt}$	-0.00778***	-0.01323***	-0.00771***	-0.00873***
	(0.00161)	(0.00136)	(0.00244)	(0.00295)
ring-fencing$_{jt}$ × *Quarter-ends*				-0.00243
				(0.00584)
N	577728	577728	577728	577728
R^2	0.94	0.93	0.93	0.96
Counterparty × Day FE	No	No	Yes	Yes
Counterparty × Month FE	Yes	No	No	No
Counterparty × Year FE	No	Yes	No	No
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes
Dealer FE	Yes	Yes	Yes	Yes
Credit rating FE	Yes	Yes	Yes	Yes
Dealer Controls	Yes	Yes	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes
PANEL B	(1)	(2)	(3)	(4)
Repo Rate	Aggregate Liquidity			Collateral Risk
ring-fencing$_{jt}$	-0.01324***	-0.01473***	-0.01332***	-0.0205057***
	(0.00161)	(0.00235)	(0.00215)	(0.0021614)
Log(Central Bank Reserves)	-0.19663***			
	(0.04308)			
Log(Central Bank Bond Holdings)		0.12611***		
		(0.03514)		
Δ*(Central Bank Reserves)*			-0.00010	
			(0.00012)	
ring-fencing$_{jt}$× Δ*(Central Bank Reserves)*			-0.00090	
			(0.00139)	
ring-fencing$_{jt}$× *High-Price volatility*				0.0294654***
				(0.0012236)
N	577728	577728	577728	592533
R^2	0.93	0.93	0.93	0.9512
Counterparty × Day FE	No	No	Yes	Yes
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes
Dealer FE	Yes	Yes	Yes	Yes
Credit rating FE	Yes	Yes	Yes	Yes
Dealer Controls	Yes	Yes	Yes	Yes
Deal Controls	Yes	Yes	Yes	Yes

NOTES: This table reports the heterogenous impact of ring-fencing on the repo rates at the level of the banking groups with robustness checks. Panel A reports the baseline specification using different specifications and fixed effects. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. Panel B presents the results controlling for different measures of quantitative easing (QE) and types of collateral risk. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

Table A10. Court Approval and Implementation

Repo Rate	(1)	(2)	(3)	(4)	(5)
ring-fencing$_{jt}$	-0.01095***	-0.01040***	-0.00512	-0.00401	-0.00618
	(0.00162)	(0.00188)	(0.00512)	(0.00457)	(0.00406)
implementation$_{jt}$	-0.00815***	-0.00287***	-0.00814***	-0.00556***	-0.01079***
	(0.00105)	(0.00103)	(0.00177)	(0.00091)	(0.00169)
log(assets)			0.03289*	0.02774*	0.00026
			(0.01735)	(0.01650)	(0.01440)
leverage ratio			0.00798***	0.01066***	0.00061
			(0.00269)	(0.00360)	(0.00135)
ROA			0.00015	-0.00019	0.00173***
			(0.00067)	(0.00079)	(0.00048)
liquidity coverage ratio			-0.00024	-0.00027*	-0.00035***
			(0.00015)	(0.00015)	(0.00011)
loans/deposits			0.00035	0.00023	0.00036**
			(0.00033)	(0.00030)	(0.00017)
haircut				-0.00022***	-0.00011
				(0.00006)	(0.00007)
log(amount)				0.00001	0.00058*
				(0.00055)	(0.00033)
log(maturity)					0.01659***
					(0.00145)
high price volatility					0.01553***
					(0.00125)
N	2377818	2229620	837642	837636	578211
R^2	0.95	0.96	0.95	0.95	0.96
Counterparty × Day FE	Yes	Yes	Yes	Yes	Yes
Counterparty-Subsidiary Type FE	Yes	Yes	Yes	Yes	Yes
Dealer FE	No	Yes	Yes	Yes	Yes
Credit rating FE	No	Yes	Yes	Yes	Yes
Dealer Controls	No	No	Yes	Yes	Yes
Deal Controls	No	No	No	Yes	Yes

NOTES: This table reports the impact of ring-fencing on the repo rates at the level of the banking groups after the ring-fencing asset transfer and the regulatory implementation, respectively. *ring-fencing*$_{jt}$ is one if the dealer banking group j is approved by the Court to establish an operational RFB subsidiary at time t, and zero otherwise. *implementation*$_{jt}$ takes one if the ring-fenced dealer banking group j completes the ring-fencing requirements in 2019, and zero otherwise. The bottom of the table provides information about fixed-effects. Standard errors correct for clustering at the lender-level, and are reported in parentheses. ***, ** and * indicate statistical difference from zero at the 1%, 5% and 10% levels, respectively.

B Further discussion of alternative potential mechanisms

This section extends the discussion of conceivable alternative explanations of our results in Section 8. We complete the analysis of the theories which were not address in Sections 8.1 through 8.3.

B.1 Ring fenced groups become more exposed to the Leverage Ratio altering their repo prices

Repo borrowing (*i.e.* receiving cash) increases the size of the balance sheet. Increases in repo can therefore require extra capital if the non-risk-weighted Leverage Ratio cap introduced in the Basel 3 rules is binding.[48] It is theoretically possible that because of ring-fencing, affected banking groups become particularly constrained by the leverage ratio. If this were the case then lending would be more expensive for the bank and so this could explain our reverse repo results.

There is no doubt that when the leverage ratio is binding it can alter banking behaviour, such as the volume of liquidity supplied via repo (Allahrakha et al., 2018; Kotidis and Van Horen, 2018).[49] We have already shown however that ring-fencing has not had an impact on volumes of repo as would be expected if the leverage ratio were binding (Allahrakha et al. (2018)). This lack of a volume effect was established above in Section 8.2 and especially Table 10.

We also note that nettable transactions do not alter the size of the balance sheet and so would not be subject to a cost effect arising from the LR.[50] However Section 8.3 and especially Table A4 established that our results hold amongst nettable trades, just as they hold amongst all trades. Furthermore, we find that our results are left unchanged at the quarter-ends where the leverage ratio is likely to be more binding (see Panel A of Table A9).

These three observations offer strong evidence against the theory that the Leverage Ratio underlies the repo price results we document.

We can offer even more direct evidence against any theory which places liquidity cost behind the repo price effects which we identify. We do this by studying the characteristics of ring-fenced banking groups which see the greatest change in their risk appetite.

To this end, we sort dealer banks into buckets of different levels of size, liquidity, and capitalization in a one-year rolling window. We define a dealer bank as small if the bank has a size smaller than the country median within the given year. In a similar vein, we classify a dealer bank as illiquid (low capital) if its liquidity coverage ratio (capital ratio) is lower than country median at a given time. We then augment our baseline specification (7) by interacting the $\textit{ring-fencing}_{jt}$ with these indicator variables in a triple-diff-in-diff setting.[51]

Table 11 reports the results of this analysis. For the purposes of our discussion here we use Column 1 of Table 11. We see that illiquid dealers are no more likely to lend cash at higher prices than liquid dealer banks: the coefficient of the variable $\textit{ring-fencing}_{jt} \times \textit{Illiquid Dealer}$ is not significant.

So we conclude that liquidity differences do not explain the evidence we have presented.

[48] There is no balance sheet impact from reverse repo (*i.e.* cash lending), Kotidis and Van Horen (2018).

[49] Allahrakha et al. (2018) show that after the implementation of LR, the U.S. dealers reduced their use of repo borrowing. Relatedly, Kotidis and Van Horen (2018) document that the LR had a negative impact on repo borrowing in the dealer-client gilt repo market.

[50] For more detail as to why the LR capital charge does not apply if the transactions are nettable see (BIS CGFS, 2017).

[51] We document the rolling-window-regressions for confidentiality reasons but sorting the dealers based on their pre-treatment characteristics does not change the qualitative interpretation of our results.

B.2 Might lower RFB borrowing costs be because of a simpler balance sheet?

Indirect evidence against this proposition arises from the observation that we have found that the whole banking group, which contains a ring-fenced subsidiary, is able to borrow at lower rates. If a banking group could arrange this benefit for itself without ring-fencing regulation, and purely through a restructuring of its retail operations, then one would have expected them to do so before ring-fencing was introduced.

More direct evidence is also available by exploiting the heterogeneity of the repo pricing effect. We return to Table 11 which reports the interaction between the $\textit{ring-fencing}_{jt}$ dummy and the *Small Dealer* indicator that sorts banks based on their size. Column 2 of Table 11 shows that the size of the dealer bank has no explanatory power in explaining the impact on the price of liquidity. Large dealer banks are likely to be more complicated. The result we find suggests that as the effects on risk appetite are not due to dealer bank size, they are therefore likely not due to balance sheet complexity.

B.3 Ring-fencing results in changed counterparties due to a 'search for yield', resulting in higher lending prices

This proposed alternative hypothesis can be explored in the same manner that the simpler-balance-sheet rationale was in Section B.2. Once again we observe that we have found that ring-fencing lowers the cost of borrowing cash for the whole banking group. If this benefit was available by altering the client mix then banks would likely have done this before ring-fencing was introduced.

More directly we study the heterogeneity of the repo pricing effect with respect to cross-sectional variation across the repo counterparties. If the price increase the RFB banking group is able to charge arises from a change in counterparties, then we should see the high prices being manifest mostly in the new counterparty relationships which the RFB group creates. To test for this effect we define an indicator variable *counterparty with new relationship* that is one if the counterparty established a new trading relationship with the dealer in the repo market. We then augment the baseline specification with this indicator variable and report our findings in Column 5 of Table 11.

The results state that the increase in the cost of repo provision is no more pronounced for counterparties with whom the dealer banks just started trading than with those with whom they previously transacted. This suggests that banks are no more likely to increase the prices of the offered repo with their new counterparties than with their frequent borrowers with whom they enjoy a banking relationship[52].

We therefore conclude that a 'search for yield' hypothesis is unlikely to be a good explanation for the evidence we document.

B.4 Counterparties willing to pay more for reliable repo partner

An alternative mechanism which has been proposed to us is that ring-fenced subsidiaries might be more reliable partners (rather than less risky as we propose) and so borrowers are willing to pay higher rates to these lenders as these reliable lenders will prioritise their clients in any future unexpectedly difficult periods. This hypothesis builds off the insight that more reliable partners

[52] We also define an indicator variable *Small Counterparty* that is one if the total number of transactions conducted by the counterparty is less than the median number of the total transactions in the repo market. We then augment the baseline specification with this indicator variable and report our findings in Column 4 of Table 11. The results state that the ring-fenced dealers increase the cost of repo provision to a greater extent for the smaller counterparties that transact less frequently, also consistent with their greater risk aversion.

are rewarded with more generous contracts as an investment in the relationship (Mojir and Anbil (2022)).

While we believe that this is likely a powerful mechanism in some economic interactions, it is not, in our view, a strong candidate to explain the results we have found here for three reasons.

The first observation is that the lower risk third parties perceive applies to the whole group containing the ring fenced bank, and not the ring fenced bank alone. This was the finding in Section 7. Second, we noted above (Table 11, Column 1) that dealer banks which are more liquid, or larger (Column 2) are no more likely than other groups containing a RFB to be able to charge higher prices to lend through reverse repos. One would expect a liquid or a large bank to be particularly reliable as it is most able to lend in good and in stressed times – there is no such distinction in evidence. Thirdly dealer banks which have the lowest capital ratios are the banking groups which see the greatest increase in their ability to charge a high price when lending – Column 3 of Table 11 – so these formerly less capitalised banks gain the most in being seen as safer from ring fencing. If reliability had been at issue we would expect the dealer banks with the largest capital ratios to be the most reliable.

So we conclude that reliability is unlikely to be the explanation for the results we have documented.

B.5 Banks argue ring-fencing was not beneficial, so can't be a bonus

It is true that banks have been against the introduction of ring fencing for a long time.[53] However some of this reluctance likely concerned one-off implementation costs rather than an assessment of any increase in variable costs. Nonetheless we note that even if ring fencing allows the affected banking group to borrow cash more cheaply (and be seen as less risky) that does not necessarily imply that ring-fencing increases the banking group's profitability overall. Ring fencing may alter the composition of the asset side of the bank (for example if a ring-fenced bank found itself overweight in UK mortgages). The overall impact of ring fencing on bank profitability is therefore not fully determined by the risk effects of ring fencing we explore in our analysis.

[53] See *e.g.*, Banks set for clash with UK regulator over ringfencing rules, *Financial Times*, 8 February 2021, Ring-Fencing and Proprietary Trading Review Barclays Response to the Call for Evidence, *Barclays Bank*, 2022, The outdated ring fence that will starve City of London finance, *Financial Times*, 27 April 2015.