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Loan pricing in internal capital markets and the impact of the two-tier system – Finance groups in Germany

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Non-technical summary

Research Question

Bank holding companies and finance groups reallocate liquidity internally via internal capital markets. These markets play a major role for the interbank money market in the euro area. We analyze the drivers of loan pricing and volumes in the unsecured and secured German interbank money market, comparing the internal capital markets of finance groups with the rest of the market. In this respect, we investigate the reduction of the deposit facility rate and the implementation of the two-tier-system for remunerating excess reserve holdings in the Eurosystem as well as the importance of relationship lending.

Contribution

To our best knowledge, we are the first to analyze the drivers of loan pricing and volumes of intra-group transactions. We also add to the literature on relationship lending by analyzing its importance in the German interbank money market and particularly in internal capital markets. We also contribute to the literature on the implications of monetary policy measures. In particular, we assess the impact of the two-tier system on loan pricing and volumes in the interbank money market, a topic that is barely covered by the existing literature.

Results

We find that head institutes tend to lend a larger amount at a lower spread to affiliated banks compared to lending to banks outside of their internal capital markets. Analogously, this also holds for head institutes borrowing from their affiliated banks. Our findings also suggest that in general, relationship lending measured by the frequency of past transactions between a bank pair is associated with a lower spread but it plays only a minor role in internal capital markets. In addition, we find evidence of heterogeneous effects of the two-tier system. It led to a slight transitory increase in rates and to a persistent increase in loan volumes in internal capital markets but not in the rest of the interbank money market.

Nichttechnische Zusammenfassung

Fragestellung

Bankkonzerne und Finanzgruppen verteilen Liquidität innerhalb ihrer Gruppen über interne Kapitalmärkte. Diese Märkte sind ein wichtiger Teil des Interbankengeldmarktes im Euro-Währungsgebiet. Wir analysieren die Treiber der Kreditzinssätze und -volumina im deutschen Interbankengeldmarkt und vergleichen die internen Kapitalmärkte von Finanzgruppen mit dem übrigen Interbankengeldmarkt. In dieser Hinsicht untersuchen wir auch den Einfluss der Senkung des Zinssatzes der Einlagefazilität und der Einführung des zweistufigen Systems für die Verzinsung von Überschussreserven (*„Tiering-System")* sowie die Bedeutung von Kreditbeziehungen.

Beitrag

Nach unserem Kenntnisstand analysieren wir als Erste die Treiber der Kreditzinssätze und -volumina für gruppeninterne Transaktionen. Darüber hinaus liefern wir einen Beitrag zur Literatur zu Kreditbeziehungen, indem wir deren Bedeutung für den Interbankengeldmarkt in Deutschland und insbesondere für interne Kapitalmärkte analysieren. Wir tragen darüber hinaus zur empirischen Literatur bei, die die Wirkungsweise geldpolitischer Maßnahmen untersucht. Insbesondere analysieren wir die Auswirkungen des *Tiering-Systems*auf die Kreditzinssätze und –volumina im Interbankengeldmarkt. Dazu gibt es bisher kaum Literatur.

Ergebnisse

Wir zeigen, dass Zentralinstitute an Banken innerhalb ihrer internen Kapitalmärkte tendenziell Kredite mit einem höheren Volumen und zu einem niedrigeren Zinsaufschlag vergeben als an Banken außerhalb ihrer internen Kapitalmärkte. Dies gilt analog auch für Zentralinstitute, die bei Banken ihres Verbundes Kredite aufnehmen. Unsere Ergebnisse deuten auch darauf hin, dass Kreditbeziehungen, gemessen an der Anzahl der vergangenen Transaktionen zwischen zwei Banken, mit einem geringeren Zinsaufschlag einhergehen. Für interne Kapitalmärkte spielen Kreditbeziehungen hingegen nur eine untergeordnete Rolle. Darüber hinaus finden wir Hinweise auf eine unterschiedliche Wirkung des *Tiering-Systems*. Es führte zu einem leichten temporären Anstieg des Zinssatzes und zu einem anhaltenden Anstieg des Kreditvolumens in internen Kapitalmärkten, jedoch nicht im Rest des Interbankengeldmarktes.

Bundesbank Discussion Paper No 30/2022

Loan pricing in internal capital markets and the impact of the two-tier system - Finance groups in Germany*

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Abstract

This paper sheds light on the functioning of internal capital markets by analysing money market transactions within the German cooperatives and savings banks finance groups. Using a unique dataset, the money market statistical reporting, this is the first paper to explicitly analyze the determinants of loan rates and volumes in internal capital markets. We find that the functioning of internal capital markets diverges substantially from the non-group interbank money market. Head institutes lend larger amounts at lower spreads to their affiliated banks than to banks outside their internal capital markets. Our findings also suggests that relationship lending is associated with lower spreads in the unsecured market in general but it plays only a minor role in internal capital markets. This finding indicates that counterparty credit risk and information asymmetries are less relevant within internal capital markets. We find an almost full immediate pass-through of the reduction of the deposit facility rate in 2019 to internal capital markets, but not to the rest of the interbank money market. The introduction of the two-tier system led to a slight transitory increase in rates and to a persistent increase in loan volumes within internal capital markets but not in the rest of the interbank money market.

Keywords: internal capital markets, monetary policy, interbank money market, relationship lending

JEL classification: E44; E43.

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1 Introduction

Bank holding companies and finance groups reallocate liquidity internally via internal capital markets. Such intra-group loans account for around half of all interbank loans in the euro area (Morandi and Nicoletti (2017)). Numerous studies provide evidence of the existence of internal capital markets and their impact on lending activities of affiliated banks (see e.g. Houston, James, and Marcus (1997), Cetorelli and Goldberg (2016)). This paper focuses on money market transactions in internal capital markets, i.e. loans with a maturity of up to 397 days. In general, the remuneration of money market loans matters because it foremost affects the short-term funding costs and internal transfer prices of banks. Both in turn are important drivers of lending conditions to the non-financial private sector (see e.g. Illes, Lombardi, and Mizen (2019), Cadamagani, Harimohan, and Tangri (2015)).

To our best knowledge, so far no study has investigated the determinants of loan volumes and rates in internal capital markets because generally intra-group transactions are not reported, e.g. in the Target2 or e-MID data. This paper aims at filling the gap. For this purpose, we use the money market statistical reporting (MMSR) dataset, which includes transactions between euro area monetary financial institutions (MFIs). While this dataset does not comprise transactions within bank holding companies, it does include transactions between head institutes and retail institutes within the savings banks and cooperatives finance groups in Germany.

Finance groups play a large role in the German banking sector, accounting for around 60% of total lending to the non-financial private sector in Germany and for 40% of total assets in the national banking system. Their organizational structure resembles a core-periphery network in which the head institutes function as money-center banks[1] for smaller affiliated banks. The head institutes act as relationship lenders and borrowers, with only about 10% of the borrowing transactions of cooperatives and savings banks taking place outside their respective group.

German finance groups display a range of similarities to bank holding companies: Finance groups are legally binded through ownership (cooperatives and savings banks own the head institutes through their associations). Groups' entities agree on common business objectives and governance rules. Finance groups use their network to reallocate liquidity internally. For this purpose, they share certain services, e.g. clearing and capital market financing. Given these similarities to bank holding companies, our findings are also informative for internal capital markets in general. Besides the similarities finance groups differ in mainly two properties from bank holding companies. First, a regional principle prohibits competition between cooperatives or savings banks across regions. Second, groups' entities offer mutual guarantees against default based on a strict monitoring system (the so called institutional protection scheme (IPS[2])).

Using panel fixed effects models, we investigate whether the price and volume of loans in internal capital markets of the two German finance groups diverge from the rest of the interbank money market. In this respect, we also investigate the impact of two ECB monetary policy measures on the interbank money market. In particular, we look at the

[1] Money-center banks are intermediaries in the interbank money market, whereas smaller banks are usually either lenders or borrowers.

[2] The IPS offers protection to its members by ensuring their liquidity and solvency.

reduction of the deposit facility rate (DFR) by 10 basis points on 18 September 2019 and at the implementation of the two-tier system (TTS) for reserve remuneration on 30 October 2019. The two-tier system exempts part of banks' excess liquidity holdings from negative remuneration.

The sample period starts on 2 January 2017 and ends on 30 December 2020. Our sample comprises secured and unsecured transactions within internal capital markets and in the rest of the interbank money market up to a maturity of 397 days. 99% of intra-group transactions (i.e. head institute lends to affiliated bank) in the MMSR data are classified as unsecured. With a share of 83%, intra-group transactions also dominate the total unsecured German interbank money market. At the same time, transactions within the finance groups' internal capital markets are protected through the IPS and thus similar to secured transactions.

In order to control for all observed and unobserved, time varying lender and borrower heterogeneity, we include lender-month and borrower-month fixed effects (Jiménez, Ongena, Peydró, and Saurina (2014)). We also add several pair-wise variables which control for heterogeneity at the bank-pair level. Our particular interest lies on an internal capital market dummy and on those variables which measure the intensity of a lending relationship. These variables are calculated based on the number of transactions or loan volumes between a bank pair over a rolling window comprising the past 30 days. The literature shows that such relationship lending variables play a crucial role for the intensive margin in the interbank money market (see e.g. Bräuning and Fecht (2017), Furfine (2001)).

We find that head institutes lend to their affiliated banks on average at a 5 bps lower spread compared to bank pairs in the non-group interbank money market. When controlling for time-varying lender heterogeneity, head institutes still lend at 4 bps lower spread to their affiliated banks compared to lending to a non-affiliated bank. These findings suggest that internal capital markets are beneficial for the smaller affiliated banks, in our case cooperatives and savings banks. Still, around 10 % of them also borrow from banks outside their respective group. When controlling for time-varying borrower heterogeneity, only those cooperatives and savings banks add to the identification of the group dummy which also trade with banks outside their respective group within a given month. We find that these banks pay on average a 5 bps higher spread when borrowing from their head institutes compared to borrowing from banks outside their respective finance group. Receiving funding from within the internal capital market is very attractive for group members because of low search costs and regulatory privileges. Therefore, cooperatives and savings banks would only borrow from non-group banks if they receive a compensation for abstaining from these benefits. Our findings suggest that a lower spread could be a push factor to acquire funds from outside internal capital markets.

Regarding the effect of ECB monetary policy measures, we find that when the ECB Governing Council reduced the DFR by 10 bps on 18 September 2019, on the same day 8 bps were passed through by head institutes when lending to affiliated banks. On the day the TTS started (30 October 2019), cooperatives and savings banks still borrowed at a 7 bps lower rate, on average, from their head institutes relative to the period before the DFR cut. At the same time, we do not find a statistically significant impact of the monetary policy measures on the lending rate in the non-group interbank money market. Our findings suggest that (i) the implementation of the TTS did not cause a permanent

increase in interbank market rates. Only in the finance groups' internal markets it led to a slight increase in the deal rate, which was only of temporary nature though. (ii) Despite the market tensions in the Covid period, after 1.4 years about 59% of the DFR cut was still present in the internal money market of German finance groups when considering transactions in which head institutes lend to their affiliated banks.

Furthermore and in line with the literature, we find that relationship lending as measured by the frequency of past interactions is associated with a lower spread (Bräuning and Fecht (2017), Furfine (2001)). In particular, when controlling for lender-time and borrower-time fixed effects, an increase by a factor of four (corresponds to around 1 standard deviation increase from the mean) in the number of loans that a bank j has borrowed from a given lender i during the past 30 days is associated with a decrease in the spread by 5 bps. Our findings are consistent with the hypothesis that repeated interactions between a bank pair reduce asymmetric information about the borrower's default risk, leading to cost savings for the lender and eventually to lower rates (Petersen and Rajan (1994)). This hypothesis is also consistent with our finding that unlike in the unsecured market, repeated interactions are not associated with a lower spread in the secured market.

In contrast to the rest of the interbank market, we find that relationship lending plays only a minor role in internal capital markets. This finding is in line with the assumption that head institutes should possess sufficient information on members' financial situation to assess their credit risk. Therefore, the additional informational benefit of each transaction should be much smaller than for banks outside of internal capital markets. More importantly, being part of the same finance group, there should be no search cost for an affiliated bank that wants to trade with its head institute such that an additional trade should not lead to efficiency gains in search costs.

The remainder of the paper is organized as follows. Section 2 gives a short overview of the related literature. Section 3 explains the main characteristics of the savings banks and cooperative finance groups. Section 4 illustrates the data we use and provides some descriptive analyses. Section 5 defines the main variables of interest and explains our empirical approach. Section 6 discusses the results.

2 Related literature

A broad finding in the literature is that bank holding companies and finance groups engage in different forms of intra-group liquidity and capital transfers, often referred to as 'internal capital markets'. One of the incentives to exchange liquidity internally is that information asymmetries and other frictions can make it costly for smaller entities to access external wholesale funding (see Houston et al. (1997)). Furthermore, some smaller entities do not have access to external wholesale markets, which makes them even more dependent on internal funding sources (see Cremers, Huang, and Sautner (2011)).

Using data from the annual statements of multinational banks and their foreign subsidiaries in the EU, Allen, Gu, and Kowalewski (2011) confirm the relevance of internal capital markets. They provide direct evidence on different forms of intra-group transactions such as asset and income transfers, loans and deposits as well as off-balance sheet transactions (Allen et al. (2011)).

A broad range of literature finds indirect evidence for the existence of internal capital markets, usually by showing that financial variables at the parent bank level are correlated

with variables at the subsidiary level. For instance, Haas and Lelyveld (2010) show that multinational banks' foreign subsidiaries have higher overall credit growth when their parent bank is more profitable. Houston et al. (1997) show that US banks' overall loan growth at the subsidiary level is more sensitive to the parent bank's capital and cash flow than to its own capital and cash flow. Cetorelli and Goldberg (2012) show that the strength of a funding shock at the parent bank is positively correlated with the withdrawal of liquidity from its affiliates abroad. For Germany, Frey and Kerl (2015) confirm the existence of internal capital markets. Analyzing the 68 largest German banks and their affiliates abroad, the authors show that internal capital markets are an important source of affiliates' funding.

While the literature on internal capital markets is centered on multinational bank holding companies, Cremers et al. (2011) analyze an internal capital market of a finance group which is more similar to the kind of internal capital markets that we describe in this paper. Cremers et al. (2011) analyze a finance group that comprises 181 retail member banks and their headquarters organization.[3] The member banks jointly own the headquarters organization and they, in turn, are owned by their local depositors. The authors use transaction data from January 2005 to September 2007, which they derive from the group's internal managerial accounting system. While the member banks do not have access to external capital markets, the headquarters runs an internal capital market allowing member banks to reallocate their liquidity within the group. According to Cremers et al. (2011), within the finance group affiliated banks are charged the same interest rate, which is therefore independent of banks' credit risk. Cremers et al. (2011) also show that more profitable member banks and those that have more influence within the group receive more funding from the headquarters organization. Due to the finding of a negative correlation between member banks' deposit growth and their net funding from the headquarters organization, the authors conclude that the headquarters insures member banks against funding shocks.

While the literature provides evidence for the existence of internal capital markets, it does not give much insight into the pricing of such intra-group transactions. Our research aims to fill this gap in the literature. We not only demonstrate that finance groups' internal capital markets play a substantial role in the German interbank market, we also analyze to what extent the pricing of loans within these internal capital markets systematically differs from the rest of the market. Moreover, we are interested in the impact of relationship lending on interbank lending rates and whether this impact differs in internal capital markets. This part of our analysis is closely related to the literature on relationship lending in interbank markets, which is fairly extensive and covers different periods and countries such as the US and Germany.

For instance, Bräuning and Fecht (2017) show that in Germany relationship lending matters for both the availability and the price of interbank liquidity because it reduces asymmetric information about counterparty risk. Using daily panel data on unsecured overnight loans, the authors show that the existence of a close lending relationship between two banks increases the likelihood of a new loan between those banks. Moreover, they find that banks that trade more frequently do so at lower rates, especially during the liquidity crisis in 2007. The authors use transaction data from the Deutsche Bundesbank's

[3]The name of the banking group and the country in which it operates are undisclosed in the paper to maintain confidentiality.

RTGSplus system. Unlike the MMSR data that we use in this paper, the authors' dataset does not allow them to identify interbank loans and interest rates directly, which is why they use an algorithm similar to Furfine (1999) to derive them. However, their dataset does not capture transactions within finance groups' internal capital markets that we study in this paper.

Other studies confirm the benefits of relationship lending in interbank markets. Furfine (1999) shows that relationship lending in the US federal funds market is beneficial for borrowers. He finds evidence that a stronger relationship between lender and borrower, measured by the pair's number of transaction days in each quarter, corresponds to lower rates. Similarly, Afonso, Kovner, and Schoar (2013) find that borrowers in the US interbank market receive lower rates from their most important lenders. Using data on unsecured overnight transactions in the Portuguese interbank market, Cocco, Gomes, and Martins (2009) show that relationship lending is not only beneficial to borrowers but also to lenders. In particular, a higher lender preference index (i.e. the volume share of loans that bank i lends to bank j) corresponds to higher rates, demonstrating that lenders require a premium as compensation for the higher concentration risk. In addition, the authors find that larger banks receive better rates, irrespective of whether they are borrowers or lenders. Temizsoy, Iori, and Montes-Rojas (2015) analyze unsecured overnight transactions on e-MID, an electronic platform for interbank deposits that is used by banks from various EU countries. Similar to Cocco et al. (2009), the authors find that relationship lending in terms of lending/borrowing concentration is beneficial for both lenders and borrowers and corresponds to higher trading volumes.

3 Characteristics of the cooperatives and savings banks finance groups

German finance groups are a network of large head institutes and smaller affiliated banks, which are cooperatives or savings banks. These smaller banks are predominantly retail banks, whereas the head institutes engage mainly in wholesale businesses. Head institutes' statutes assign them above all the role of a central bank within their respective finance group. Thus, their main task is to distribute liquidity within their group (i.e. liquidity clearing service): They channel liquidity from those affiliated banks that have a surplus to those that need liquidity.

German finance groups display a range of similarities to bank holding companies: Finance groups are legally binded through ownership (cooperatives and savings banks own through their associations the head institutes). Groups' entities agree on common business objectives and governance rules. Finance groups use their network to reallocate liquidity internally. For this purpose, they share certain services, e.g. clearing and capital market financing. Given these similarities to bank holding companies, our findings are also informative for internal capital markets in general.

Intra-finance group loans account for about 40% of all interbank loans in Germany. Looking at the two finance groups, head institutes extend around 60% of their total interbank loans to members of their respective finance group. The fact that intra-group loans are so important for member banks is due to a certain institutional structure and regulatory privileges. Finance group members commit to an institutional protection scheme

(IPS). The IPS protects its members, regardless of their size, by ensuring their liquidity and solvency (Article 113(7) CRR, 1st paragraph). This implicit non-default guarantee distinguishes the cooperatives and savings banks finance groups from privately owned bank holding companies. The IPS monitors its member banks, which have to fulfill regular reporting requirements and comply with IPS-specific guidelines for risk management. An early warning mechanism aims to identify liquidity and solvency risks at member banks and initiates resolution mechanisms. As a consequence, the IPS reduces counterparty risk and information asymmetries in the group network.

Banking supervision has recognized the German IPSs of each finance group as eligible for the purposes of Regulation (EU) 575/2013 of the European Parliament and of the Council (CRR) within the Single Supervisory Mechanism (SSM). On these grounds, various regulatory privileges apply to IPS member institutions.[4] On the one hand, they include reductions and waivers in clearing obligations and own funds requirements.[5] Bank holding companies also receive these privileges. On the other hand, IPS member banks are eligible to exclusive privileges on top, such as applying waivers for liquidity requirements and having their own deposit guarantee schemes.[6] As a consequence, intra-group deposits are treated as guaranteed retail deposits independently of their maturity and are therefore considered as highly stable liabilities from a regulatory perspective.[7] The head institutes in both finance groups depend on these intra-group deposits to fulfill their regulatory liquidity ratios.

A difference between the cooperatives and savings banks finance groups is related to the minimum reserve requirement. Euro area banks have to hold those reserves on accounts with their national central bank. In contrast to the head institutes in the savings bank finance group, the cooperatives' head institute fulfills the minimum reserve requirement (MRR) not only for itself but also for some affiliated banks. Therefore, the reserve base of the head institute which is used to determine the MRR is the sum of deposits held by the head institute and deposits held by those affiliated banks that do not hold reserves with Deutsche Bundesbank.[8] Around 50% of the cooperatives in our estimation sample choose to hold the minimum reserve requirement indirectly via their head institute.

The network structure of both finance groups resembles a core-periphery network in which the head institutes function as money-center banks for the smaller affiliated banks. Hence, the share of reciprocal transactions is low: On average, a head institute lends to an affiliated bank 20 times more often than it borrows from it within a given month. Furthermore, cooperatives and savings banks borrow mainly from their respective head institutes. Only 4% of the savings banks and 16% of the cooperatives borrow from banks outside their finance groups. Within the savings banks finance group most savings banks borrow from a single head institute. Some of them also borrow from multiple head

[4] In accordance with the conditions laid down in Article 113(7) CRR.

[5] For instance, 0% risk weight for exposures to IPS member institutions (Article 113(7) and 113(6) CRR), non-deduction of holdings of own funds instruments in IPS members (Article 49(3) and 49(1) CRR), IPS-related exposures are exempted from large exposure requirements (Article 400(1)f CRR).

[6] For alleviation in the liquidity regulation see Regulation (EU) No 575/2013.

[7] Regulation (EU) No 575/2013, Article 422(3)b)

[8] Minimum reserves are compulsory deposits that commercial banks are required to hold with their respective euro area central bank and are calculated using the reserve base. The reserve base comprises deposits from non-banks, banks that are not subject to minimum reserve requirements and debt securities that have an agreed maturity or notice period of up to two years.

institutes: Around 20% of the savings banks in our sample borrow from more than three head institutes. By contrast, trades with other savings banks and with banks outside of their finance group play a minor role.

4 Data and descriptive analysis

4.1 Data

We analyze the pricing and the transmission of monetary policy in internal capital markets using the unsecured and secured market segment of the money market statistical reporting (MMSR) dataset of euro area MFIs. The main intention for designing the MMSR was to calculate the Euro short-term rate (€STR) which is gradually replacing EONIA in the euro area. The MMSR is based on money market transactions between the reporting MFIs and other MFIs, public entities and non-financial corporations.[9] We restrict our estimation sample to the transactions in the interbank money market reported by banks in Germany.

The German MMSR sample consists of 129 reporting agents which report every transaction up to a maturity of 397 days after settlement date.[10] MFIs are obliged to report if they use a TARGET2-Payment-Module-Account and their relevant balance sheet assets exceed €1 billion (as at end-2014). The MMSR dataset does not contain data on the intra-group transactions of bank holding companies. However, it does include intra-group transactions of the two German finance groups because cooperatives and savings banks do not own their head institutes directly but through their associations. Since the head institutes are reporting agents they have to report each transaction with their affiliated banks.

The MMSR provides the lending and borrowing transactions of the reporting MFIs.[11] Our baseline regressions and descriptive statistics are based on the lending dataset, i.e. the reporting MFI is the lender. This is because our focus is on the financing conditions of affiliated banks within internal capital markets and this data set captures lending transactions from head institutes to their affiliated banks. However, to check for robustness and to evaluate the net effect of intra-finance group transactions, we repeat all estimations with the borrowing dataset.

The MMSR dataset includes detailed attributes for each transaction. From the raw data, we use the transaction-based information on the deal rate, the traded amount, the number of trades, the maturity and whether the deal rate is fixed for some period. Based on these attributes, we construct various bank-pair variables including those capturing relationship lending.

[9] Regulation (EU) No 1333/2014 of the European Central Bank (ECB/2014/48) amended by Regulation (EU) No 1599/2015 of the European Central Bank (ECB/2015/30), amended by Regulation (EU) No 113/2019 of the European Central Bank (ECB/2018/33), amended by Regulation (EU) No 1677/2019 of the European Central Bank (ECB/2019/29) and subsequently amended by Regulation (EU) No 2004/2020 of the European Central Bank (ECB/2020/58).

[10] In the OIS segment of the MMSR all maturities have to be reported. Overdrafts are excluded from the reporting obligation.

[11] The counterpart sector of the unsecured lending transactions in the MMSR is restricted to deposit-taking corporations except the central bank. However, as we focus only on the interbank money market, this has no impact on our analysis.

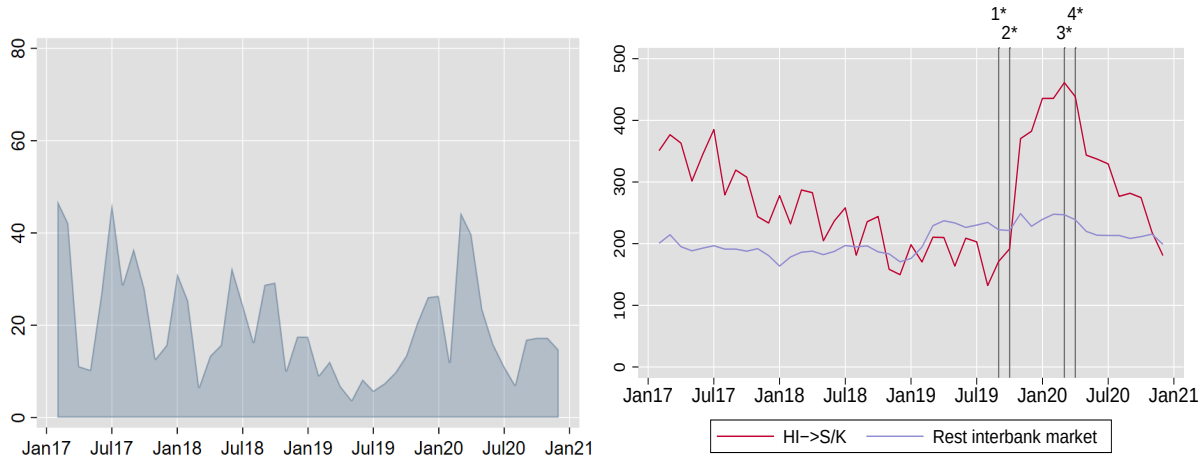
99% of intra-group transactions (i.e. head institute lends to affiliated bank) are classified as unsecured in the MMSR data. With a share of 83%, intra-group transactions also dominate the total unsecured German interbank money market. Even though most intra-group transactions are classified as unsecured, the IPS provides protection for the lender should its counterpart default. Hence, an intra-group transaction shows similarities to a collateralized trade (secured market).

We exclude transactions by central counterparties (CCPs) from the raw data, as they differ fundamentally from over-the-counter (OTC) transactions. In particular, CCP transactions do not involve search costs for the counterparties, and as these trades are mostly anonymous, the relevance of relationship lending for the intensive margin should be negligible. We also remove bank pairs with only one transaction per month from the raw data. The daily pair-wise deal rate and spread are winsorized at the 3^{rd} and 97^{th} percentiles.[12] Our benchmark estimation sample consists of 3003 bank pairs and around 468,500 daily observations. The estimation sample starts on 2 January 2017 and ends on 30 December 2020.

4.2 Descriptive analysis

During the sample period, around 56% of the daily lending transactions in the unsecured and bilateral secured interbank money market took place within the cooperatives and savings banks finance groups.[13] At the same time, intra-group transactions account on average for around 13% of the total market volume (see Figure 1).[14]

Figure 1: Importance of the finance groups for the interbank money market (lending)



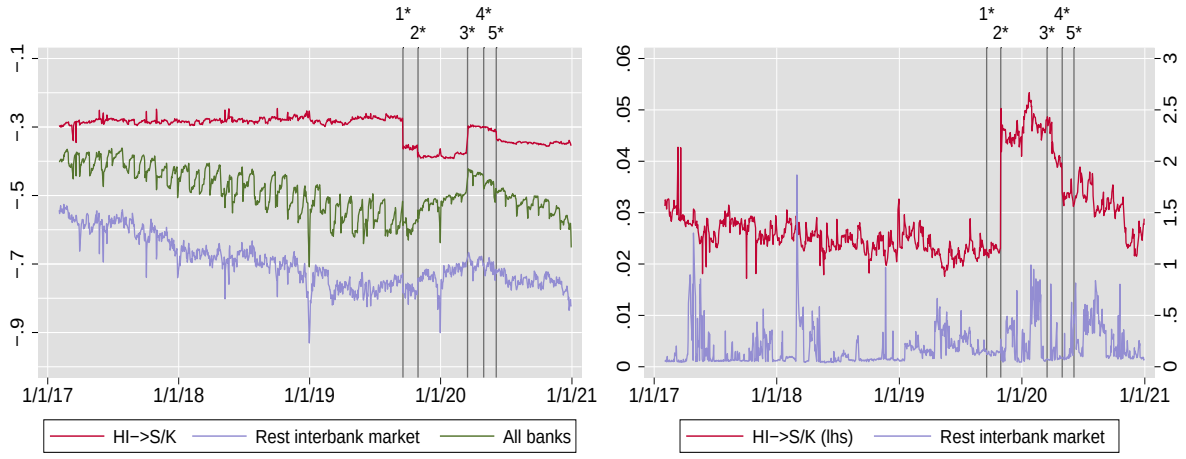
(a) Groups' share of total monthly volumes (b) Average monthly number of bank pairs

Note: In percentage (lhs). *[1=Deposit facility rate decreased by 10 bps to -0.5% on 18 Sep. 2019. 2=Two-tier system for reserve remuneration implemented in the Eurosystem on 30 Oct. 2019. 3=Covid crisis intensified in Mar. 2020. 4=ECB Governing Council on 30 Apr. 2020: easing of TLTRO-III conditions.] HI = Head Institute. K = Cooperatives. S = Savings banks. For reasons of confidentiality, only monthly data can be shown.
Source: Deutsche Bundesbank, money market statistical reporting.

[12] Our main findings are robust against no winsorizing.
[13] In the borrowing transaction dataset, this intra-group share is 47%.
[14] In the borrowing transaction dataset, this intra-group share is 5%.

Compared to the rest of the interbank money market, head institutes lend to their affiliated institutions at a 39 bps higher rate on average and with a maturity that is 9 days shorter (7 days compared to 16 days) (see Section A.3 and Figure 2). The daily average volume-weighted intra-group deal rate exhibits very low volatility over time. A low share of outliers is also indicated by the closeness of the mean and median. Similar to Cremers et al. (2011), we presume that head institutes are mostly not discriminating between their affiliated institutions. In terms of our empirical analysis, this presumption would imply that relationship lending plays a minor role in explaining intra-group deal rates.

Figure 2: Average daily pair-wise deal rate and volume (lending)



(a) Rate (b) Volume

Note: In percentage (a). In €bn (b). *[1=Deposit facility rate decreased by 10 bps to -0.5% on 18 Sep. 2019. 2=Two-tier system for reserve remuneration implemented in the Eurosystem on 30 Oct. 2019. 3=Covid crisis intensified in Mar. 2020. 4=ECB Governing Council on 30 Apr. 2020: easing of TLTRO-III conditions. 5=ECB Governing Council on 4 Jun. 2020: PEPP expansion by €bn 600.] HI = Head Institute. K = Cooperatives. S = Savings banks.
Source: Deutsche Bundesbank, money market statistical reporting.

Our sample period, which goes from January 2017 to December 2020, covers several monetary policy decisions by the ECB Governing Council. It includes the cut of the deposit facility rate (DFR) by 10 basis points on 19 September 2019 and the implementation of the two-tier system of reserve remuneration (TTS) on 30 October 2019. In March 2020, with the intensification of the Covid pandemic in Europe, the ECB Governing Council announced mitigating measures which injected large amounts of liquidity into financial markets (e.g. additional longer-term refinancing operations and a pandemic emergency purchase program (PEPP)). In April, additional measures followed such as a reduction of the interest rate on the third series of targeted longer-term refinancing operations (TLTRO-III). In this paper, however, we focus on the impact of the TTS and of the DFR cut on the interbank money market (in particular, on finance groups' internal markets). This is an important contribution to the literature, since the effect of the TTS especially has barely been investigated in the empirical literature yet.

The aim of the two-tier system is to reduce the burden of the negative interest rate policy on banks' profitability. In particular, since the introduction of the TTS MFIs are allowed to exempt six times their minimum reserve requirement (MRR) from the negative

remuneration that usually applies to excess liquidity.[15] Like the MRR, these exempted excess reserve holdings are remunerated at 0%.

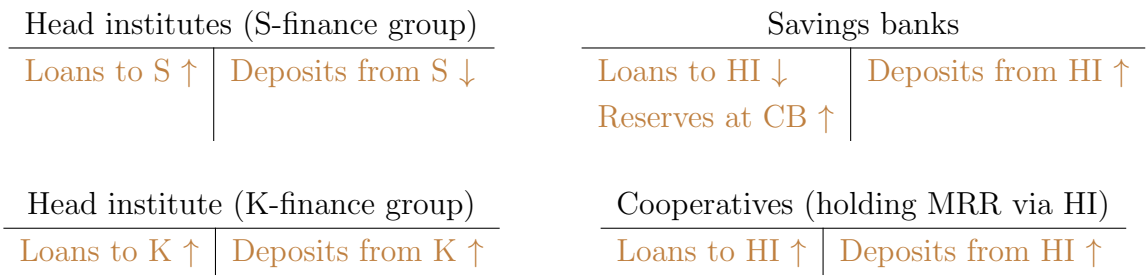
In a negative interest rate environment, liquid assets with a non-negative remuneration are relatively attractive for financial institutions and might entail balance sheet adjustments in the banking sector. Figure 1 shows that following the implementation of the TTS (vertical line number 2), the number of savings banks and cooperatives borrowing from their head institutes increased sharply. The higher number of intra-group loans was accompanied by a strong rise in traded volumes (see Figure 2). At the same time, the intra-group deal rate decreased only slightly. Its main downward adjustment was on the day of the DFR cut on 19 September 2019 (vertical line number 1).

Until the intensification of the Covid crisis in March 2020 (vertical line number 3), the number of intra-group bank pairs doubled and the intra-group volume share quadrupled. However, since then intra-group transactions and volumes have decreased steadily again. The counter movement in lending volumes since March 2020 might be related to the participation of savings banks and cooperatives in the TLTRO-III. The TLTRO-III participation had an increasing impact on their excess reserves and reduced their need for head institutes' money. As the TTS effect on intra-group lending volumes has discontinued since the beginning of the pandemic, in the rest of the paper, the term "TTS period" refers to the period between 30 October 2019 and the end of February 2020. The period before 30 October 2019 corresponds to the "pre-TTS period". The term "Covid period"refers to the period from March 2020 until December 2020, which is the end of our sample period.

Proprietary balance sheet data indicate ambiguous reasons for the increased borrowing of cooperatives and savings banks from their head institutes after the start of the TTS (see Figure 3). Savings banks deposited the liquidity inflows from their head institutes at the central bank in order to increase their excess reserve holdings. Higher excess reserves allowed them to exploit higher allowances under the two-tier system. In the cooperative sector, balance sheet adjustments were probably related to the fact that a high share of cooperatives hold the minimum reserve requirement indirectly via their head institute ("indirect MRR-holding" cooperatives). For the cooperatives' head institute to exploit the allowances as a typical wholesale bank, it aimed at expanding its reserve base which is rather low due to its business model. Therefore, those "indirect MRR-holding" cooperatives deposited the liquidity provided by the head institute in their account with the head institute. Since the deposits of banks which are not directly subject to a minimum reserve requirement are included in the reserve base calculation (see Deutsche Bundesbank (2021)), the head institute thus reached a higher exemption allowance. By contrast, the "direct MRR-holding" cooperatives adjusted their balance sheet in a similar manner as the savings banks.

[15] For a detailed description of the two-tier system, see Deutsche Bundesbank (2021).

Figure 3: Balance sheet effect of the two-tier system of reserve remuneration



Note: The effects are based on the balance sheet adjustments during the TTS period (i.e. Oct. 2019 until Feb. 2020). For reasons of confidentiality, we only show the direction of these adjustments. K = Cooperatives. S = Savings banks. HI=Head institute(s). CB = Central bank. Source: Deutsche Bundesbank, monthly balance sheet statistics.

5 Variables and estimation strategy

5.1 Variables

5.1.1 Dependent variables

We analyze the effect of banking group membership and lending relationships on both prices and transaction volumes in the German interbank market. The first dependent variable in our regression model is $Spread_{ij,t}$, the spread between the volume-weighted average interest rate of bank pair ij on day t and the volume-weighted average market interest rate on the same day, where i is the reporting agent and j the counterpart of a transaction. In the baseline regressions the reporting agent i is always the lender and the counterpart j is always the borrower in a transaction.

$$Spread_{ij,t} = \frac{\sum_{n=1}^{N_{ij,t}} (r_{ij,t,n} \times v_{ij,t,n})}{\sum_{n=1}^{N_{ij,t}} v_{ij,t,n}} - \bar{r}_t \tag{1}$$

$r_{ij,t,n}$ and $v_{ij,t,n}$ are the interest rate and loan volume, respectively, of transaction n between bank pair ij on day t. $N_{ij,t}$ is the total number of transactions of bank pair ij during day t and $\bar{r}_t$ is the volume-weighted average interest rate of all transactions carried out on day t. $\bar{r}_t$ is given by the following equation:

$$\bar{r}_t = \frac{\sum_i \sum_j \sum_{n=1}^{N_{ij,t}} (r_{ij,t,n} \times v_{ij,t,n})}{\sum_i \sum_j \sum_{n=1}^{N_{ij,t}} v_{ij,t,n}} \tag{2}$$

The second dependent variable is the logarithm of the total transaction volume of bank pair ij on day t. The variable is given by the following equation:

$$Amount_{ij,t} = \log\left(\sum_{n=1}^{N_{ij,t}} v_{ij,t,n}\right) = \log(V_{ij,t}) \tag{3}$$

5.1.2 Relationship lending variables

A special focus of this paper is the role of relationship lending for the intensive margin in the German interbank money market. In particular, we analyze whether the impact

of relationship lending on loan pricing and amounts in finance groups' internal capital markets differs from the rest of the market. For this purpose, our regression models include indices that measure the strength of a bank pair's relationship. In our baseline regression, we use two different measures based on the number of loans and on the volume of these transactions. Similar to Bräuning and Fecht (2017) and Furfine (2001), the relationship lending variable based on the frequency of past transactions $RL^N_{ij,t}$ is given by the logarithm of 1 + the total number of transactions between bank pair ij during the 30 days prior to day t:

$$RL^N_{ij,t} = log(1 + \sum {}^{30}_{s=1} N_{ij,t-s}) \tag{4}$$

Assuming that each trade contains information on a bank's counterpart, a higher number of interactions should reduce information asymmetry between a bank pair by providing the lender with private information on the borrower's creditworthiness. As argued by Petersen and Rajan (1994), this can lead to cost savings for the lender which could be passed on to the borrower through lower rates depending on the lender's market power.

The relationship variable based on the volume of past transactions $RL^V_{ij,t}$ is given by 1 + the logarithm of the total transaction volume between bank pair ij during the 30 days prior to day t:

$$RL^V_{ij,t} = log(1 + \sum {}^{30}_{s=1} V_{ij,t-s}) \tag{5}$$

A higher amount traded may correspond to a higher concentration of lender $i's$ lending to borrower j and/or a higher dependence of borrower j on lender i. In both cases, we would expect a positive relation between the spread and $RL^V_{ij,t}$. In the first case, the lender should demand a higher compensation for the higher concentration risk. In the second case, a higher dependency of the borrower would mean a greater market power for the lender, which the lender could exploit by charging a higher rate (see Bräuning and Fecht (2017)).

In the robustness analyses we use alternative relationship lending variables which measure the strength of a pair's relationship from the lender's and the borrower's perspective, respectively. The lender preference index based on volumes measures how strongly a lender $i's$ lending volume is concentrated at a given borrower j. Similar to Temizsoy et al. (2015), it is calculated by the ratio of the total transaction volume between bank pair ij and the lender $i's$ average transaction volume per borrower during the 30 days prior to t:

$$LPI^V_{ij,t} = \frac{\sum {}^{30}_{s=1} V_{ij,t-s}}{\sum_j \sum {}^{30}_{s=1} V_{ij,t-s} / outdegree^{30}_{i,t}} \tag{6}$$

where $outdegree^{30}_{i,t}$ is the total number of borrowers that lender i has lent to during the 30 days prior to t. An index larger than 1 indicates that a lender has lent a higher loan amount to the respective borrower in the previous 30 days than it did on average during this period. Analogously, an index smaller than 1 indicates that a lender has lent a smaller amount to the respective borrower in the previous 30 days than it lent on average during this period. As outlined by Bräuning and Fecht (2017), a lender with a higher

volume-based LPI has a relatively higher credit risk concentration at borrower j and thus a higher incentive to monitor that specific borrower. This could lead to an information advantage for lender i regarding borrower $j's$ credit risk and consequently to lower rates. However, the higher monitoring costs and the higher concentration risk might also cause interest rates to rise.

The borrower preference index measures how strongly a borrower $j's$ borrowing is concentrated at a given lender i. It is given by the ratio of the total transaction volume between bank pair ij and borrower $j's$ average borrowing volume per lender during the 30 days prior to t:

$$BPI^{V}_{ij,t} = \frac{\sum_{s=1}^{30} V_{ij,t-s}}{\sum_{i} \sum_{s=1}^{30} V_{ij,t-s} / indegree^{30}_{j,t}} \tag{7}$$

where $indegree^{30}_{j,t}$ is the total number of lenders that borrower j has borrowed from during the 30 days prior to t. A higher index indicates that bank $j's$ borrowed volume is relatively more concentrated at lender i, which might imply a higher dependency of borrower j on lender i. A potential consequence might be that the lender makes use of this relative market power over borrower j by charging higher rates (see Bräuning and Fecht (2017)). As a further robustness analysis, we include the LPI and BPI based on the number of loans rather than volumes in our regression.

An important caveat of the BPI is that if a borrower has borrowed from only one bank during the previous 30 days, it is by definition equal to 1, even though the borrower's concentration is at a maximum. This might imply difficulties in comparing the BPI across banks, in particular for the finance groups where banks often trade with just one head institute. Given that the BPI has these limitations, we use $RL^{N}_{ij,t}$ and $RL^{V}_{ij,t}$ in our baseline regression.

5.2 Estimation strategy

5.2.1 Intra-group pricing and the importance of relationship lending

We analyze the pricing of intra-group transactions in the interbank money market. In particular, we are interested in whether cooperatives and savings banks borrow from their head institutes at a different spread compared to bank pairs in the rest of the interbank money market. The baseline regression model for this purpose is estimated as follows

$$Spread_{ij,t} = \beta Group_{ij} + X_{ij,t} + \mu_{i,m} + \gamma_{j,m} + \delta_t + \theta_M + e_{ij,t} \tag{8}$$

where $Spread_{ij,t}$ is the daily pair-wise spread calculated as in Equation 1. Our main variable of interest is $Group_{ij}$. It is a dummy variable equal to one if the transaction is between a head institute and a retail bank from the same finance group (i.e. a cooperative if the head institute is part of the cooperatives finance group or a savings bank if the head institute is part of the savings banks finance group). $\mu_{i,m}$ and $\gamma_{j,m}$ are lender*month and borrower*month fixed effects which control for all observed and unobserved, time-varying lender and borrower heterogeneity (e.g. Jiménez et al. (2014)). Note that if borrower*month fixed effects and $Group_{ij}$ are included in the model, $Group_{ij}$ captures only the effect of those cooperatives and savings banks which also trade with banks

outside their respective group within the same month. The same applies to the head institutes when lender*month fixed effects and $Group_{ij}$ are simultaneously included in the model. The daily fixed effects δ_t capture time-varying factors which are constant across lenders and borrowers such as end of maintenance period effects. θ_M is a dummy variable for the unsecured market which controls for time constant differences between the secured and unsecured market. Even though the idiosyncratic component of the deal rate in the internal capital market and secured market might be comparable, the base rate of the intra-group deal rate is probably an unsecured money market rate. Therefore, the difference in the group and secured market deal rates consists of a fixed component which we need to control for. Vector $X_{ij,t}$ contains the relationship lending variables (see Section 5.1.2) and further pair-wise controls at the daily level. These are the transaction volume of bank pair ij over the volume of all transactions in the market, the number of loans of bank pair ij over the number of loans in the market, the volume-weighted maturity of bank pair ij and the share of fixed rate transactions of bank pair ij over all transactions of bank pair ij. We also include two other measures that are common in the network literature: the (normalized)outdegree and indegree, i.e. the daily number of borrowers of lender i over all borrowers in the market and vice versa. A detailed description of all variables can be found in Section A.1 in the appendix. Due to this wide set of controls and fixed effects, $Group_{ij}$ plausibly captures the average internal capital market premium in the spread. $e_{ij,t}$ are robust standard errors clustered at the bank-pair level. All models are re-estimated with $Amount_{ij,t}$ as the dependent variable which is the daily transaction volume of bank pair ij.

In a further specification, we allow the effect of relationship lending to differ between the finance groups' internal capital markets and the rest of the interbank money market by interacting the relationship lending variables with $Group_{ij}$ and a non-group dummy. $nonGroup_{ij}$ is calculated as 1-$Group_{ij}$. Furthermore, relationship lending should be of greater importance in the unsecured money market, as credit risk is much more apparent in this market segment. Therefore, the econometric analysis is conducted separately for the unsecured and secured interbank money market. The respective model is given by the following equation:

$$\begin{aligned} Spread_{ij,t} =& \beta Group_{ij} + \omega_1(nonGroup_{ij} \times RL^V_{ij,t}) + \\ & \omega_2(nonGroup_{ij} \times RL^N_{ij,t}) + \omega_3(Group_{ij} \times RL^V_{ij,t}) + \\ & \omega_4(Group_{ij} \times RL^N_{ij,t}) + X_{ij,t} + \mu_{i,m} + \gamma_{j,m} + \delta_t + e_{ij,t} \end{aligned} \tag{9}$$

$RL^V_{ij,t}$ and $RL^N_{ij,t}$ are the relationship lending variables defined as in Section 5.1.2. Their correlation coefficient is 0.536 and highly statistically significant, which does not indicate collinearity. Apart from the before mentioned changes, the regression model is the same as in Equation 8. As a robustness analysis, we re-estimate the model using two different lender and borrower preference indices.

5.2.2 Monetary policy transmission

To analyze the impact of the reduction of the DFR and the implementation of the TTS on bank pairs' intensive margin, we compare different time periods with the period before the DFR cut on 18 September 2019. This reference period lasts from 2 January 2017 to 17 September 2019. It is characterized by no monetary policy rate changes or implementation

of new measures. In order to identify a potentially diverging impact of the DFR cut and the TTS on the finance groups' intensive margin compared to the rest of the estimation sample, $Group_{ij}$ is interacted with time dummy variables at the daily level. The regression model is estimated as follows:

$$\begin{aligned} Spread_{ij,t} =& \omega_1(nonGroup_{ij} \times D_t^{DFR}) + \omega_2(nonGroup_{ij} \times D_t^{18Sep<t<30Oct}) + \\ & \omega_3(nonGroup_{ij} \times D_t^{TTS}) + \omega_4(nonGroup_{ij} \times D_t^{TTS2}) + \\ & \omega_5(nonGroup_{ij} \times D_t^{Covid}) + \omega_6(Group_{ij} \times D_t^{DFR}) + \\ & \omega_7(Group_{ij} \times D_t^{18Sep<t<30Oct}) + \omega_8(Group_{ij} \times D_t^{TTS}) + \\ & \omega_9(Group_{ij} \times D_t^{TTS2}) + \omega_{10}(Group_{ij} \times D_t^{Covid}) + \\ & X_{ij,t} + \lambda_{ij} + \theta_M + e_{ij,t} \end{aligned} \tag{10}$$

where D_t^{DFR} equals one for 18 September 2019 when the ECB Governing Council reduced the DFR by 10 bps to -0.5% and zero otherwise. $D_t^{18Sep<d<30Oct}$ equals one if the transaction took place during the period between 19 September and 29 October 2019 and zero otherwise. D_t^{TTS} equals one for 30 October 2019 when the ECB Governing Council implemented the TTS and zero otherwise. D_t^{TTS2} equals one for the period between 31 October 2019 and 9 March 2020 and zero otherwise. D_t^{Covid} equals one for the period after 9 March 2020, capturing the effect of increasing market funding costs of European banks after the intensification of the Covid pandemic. The pair-wise controls are as in Equation 8. We substitute the *lender x month* and *borrower x month* fixed effects with bank-pair fixed effects, because our main interest is in the interaction term between the time and group dummy variables. By including bank-pair fixed effects we control for all pair-wise unobserved and observed heterogeneity. We do not add daily fixed effects, since they would be collinear with the time dummy variables. Still, we would expect that observations on different bank pairs are correlated on the same day, e.g. at the end of a maintenance period. We address this issue by using a two-way clustering of standard errors, at the bank-pair and daily level (Petersen (2009)).

6 Findings

6.1 Intra-group pricing and the importance of relationship lending

Our baseline regression results from Equation 8 are shown in Table 1 in the Appendix. We find that on average savings banks and cooperatives borrow 54% more and pay 5 bps less when borrowing from their head institutes than borrowers in the rest of the interbank money market (columns 1 and 5).[16] These findings are robust when controlling for time varying lender heterogeneity by including lender-month fixed effects. More specifically, on average head institutes lend 87% more to affiliated banks at a spread that is 4 bps lower than what they demand from banks outside their internal capital market (columns 2

[16]Since the dependent variable of the pair-wise amount is logarithmized, percentages are calculated as follows: $(e^{\beta_i} - 1) * 100$.

and 6). These findings suggest that internal capital markets are beneficial for the smaller affiliated banks, in our case cooperatives and savings banks. When controlling for time-varying borrower heterogeneity, only those cooperatives and savings banks add to the identification of the group dummy which also trade with banks outside their respective group within a month. [17] We find that these banks pay on average a 5 bps higher spread when borrowing from their head institutes compared to borrowing from banks outside their group.

Receiving funds from within the internal capital market is very attractive because of low search costs and regulatory privileges. Therefore, banks would only borrow from non-group banks if they receive a compensation for abstaining from these benefits. Our findings suggest that a lower spread could be a push factor to require funds outside internal capital markets. The positive coefficient of the group dummy when including borrower fixed effects could indicate that those cooperatives or savings banks which borrow from outside their respective groups are less risky than other members of their respective finance group. Hence, more risky member banks might not be able to receive more favorable rates outside their respective group. Note that when including time-varying borrower fixed effects, we control for banks' balance sheet characteristics and their riskiness. Therefore, those affiliated banks might pay relatively more within their finance groups because head institutes probably do not discriminate between member banks and offer a lending rate independent from idiosyncratic borrower risks.

In line with the literature, we find that relationship lending as measured by the frequency of past interactions is associated with lower spreads (Bräuning and Fecht (2017), Furfine (2001)). In particular, after controlling for lender-month and borrower-month fixed effects, an increase by the factor four[18] in the number of loans that a bank j has borrowed from a given lender i during the past 30 days is associated with a decrease in the spread by 5 bps (-0.038*ln(4)*100) (see column 4 of Table 1). By contrast, a higher transaction volume between a bank pair during the past 30 days is associated with a higher spread. An increase of this past transaction volume by the factor 17[19] is associated with an increase in the spread by 4 bps (0.013*ln(17)*100). The effect becomes stronger when the number of trades between the bank pair is higher (see positive interaction effect in column 2 in Table 2). Our results also show that relationship lending is generally associated with higher loan volumes. In the most robust specification with lender-month and borrower-month fixed effects, a higher number of past transactions and a higher loan volume of past transactions between a bank pair both correspond to a higher loan volume.

Our findings support the hypothesis that repeated interactions between a bank pair reduce asymmetric information about the borrower's default risk, leading to cost savings for the lender and eventually to lower rates (Petersen and Rajan (1994)). This hypothesis

[17] Around 10 % of the affiliated banks also borrow from banks outside their respective group.

[18] A quadrupling roughly corresponds to an increase by one standard deviation from the mean of the number of transactions between a bank pair during the past 30 days, see Section A.3. Note that the natural logarithm of 1 + the number of loans during the past 30 days between a bank pair is approximately equal to the natural logarithm of the number of loans during the past 30 days between a bank pair if the number of past transactions is high.

[19] This factor roughly corresponds to an increase by one standard deviation from the mean of the loan volume of a bank pair during the past 30 days, see Section A.3. Since loan volumes are measured in euro and are thus large, the natural logarithm of 1 + the loan volume is approximately equal to the natural logarithm of the loan volume.

is also consistent with our finding that unlike in the unsecured market, repeated interactions are not associated with a lower spread in the secured market (see Table 2). This points to the fact that credit risk is less relevant for secured transactions because the lender would receive the collateral in case the borrower defaults. Therefore, the benefit of learning about the counterparty's credit risk is much lower than in the unsecured market. The positive coefficient of $RL^V_{ij,t}$ could indicate that the lender demands a compensation for its higher credit risk concentration and/or that the lender exploits its relative market power over the borrower. [20]

Regarding the finance groups, we expect that, compared to lenders in the rest of the interbank money market, head institutes have sufficient ex ante information about group members' financial situation . Therefore, even though a head institute learns about its affiliated banks' credit risk with each transaction, the effect of this additional information on the intensive margin should be rather small. To allow for heterogeneous effects of the relationship variables on the intensive margin, we interact them with the finance group and non-group dummy variable. The results in Table 2 show that indeed, when controlling for borrower and lender heterogeneity, relationship lending as measured by the frequency of past transactions has no effect on the spread of interbank loans within internal capital markets (coefficient on $Group_{ij} * RL^N_{ij,t}$) but it does in the rest of the market (coefficient on $nonGroup_{ij} * RL^N_{ij,t}$). The same hold for the relationship lending variable as measured by the loan volume of past transactions $RL^V_{ij,t}$ (see Table 3), indicating that head institutes do not make use of their relative market power within internal capital markets. For transactions outside of internal capital markets, the effects of both relationship lending variables are even stronger than in the baseline regression when allowing for heterogenous effects.

Our findings suggest that the benefit of additional information about counterparties' credit risk following repeated interactions is muted within internal capital markets. An explanation besides joint ownership is that the IPS reduces credit risk and information asymmetries between groups' entities and thus, reduces the marginal benefit of relationship lending. Since information asymmetries are likely to be lower in other internal capital markets as well, our finding should also hold for internal capital markets of bank holding companies.

Our further pair-wise control variables have the expected signs. A longer maturity is associated with a higher spread. In particular, in the specification with borrower-month and lender-month fixed effects as shown in column 4 of Table 1, an increase in the weighted maturity by the factor four[21] corresponds to an increase in the spread by 10 bps on average (0.072*ln(4)*100). Furthermore, an increase in the pair-wise loan volume relative to the total daily loan volume in the market by one standard deviation (i.e. 2 percentage points (pps)) leads to an increase in the spread by 2 bps on average. An increase in the share of loans with a fixed interest rate by one standard deviation (i.e. 26 pps) is associated with a decrease in the spread on average by 7 bps. This negative relationship could reflect that lenders are willing to accept a lower interest rate in order to be insured against future

[20] Our robustness in Section 6.3 suggest that a higher past lending volume is associated with a higher spread due to the borrower's borrowing concentration rather than due to the lender's lending concentration. This suggests that the lender exploits its relative market power over the borrower.

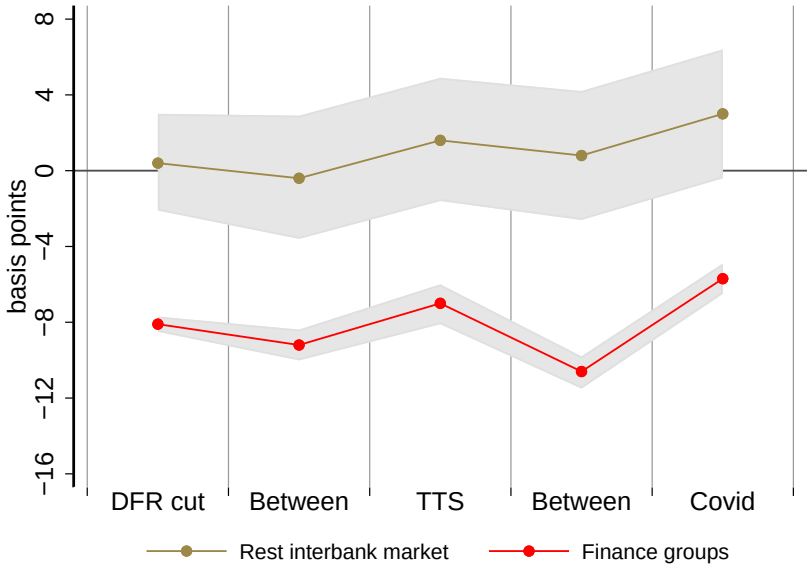
[21] A factor of four roughly corresponds to an increase by one standard deviation from the mean of the weighted maturity of a bank pair.

policy rate cuts.

6.2 Monetary policy transmission

We are interested in the effects of the reduction of the DFR by 10 bps on 18 September 2019 and of the implementation of the two-tier system on 30 October 2019 on the interbank money market. The baseline regression results from Equation 10 can be found in Table 4 in the Appendix. Apart from the pair-wise deal spread and the loan volume, we also use the pair-wise deal rate as a dependent variable since the effect on the deal rate allows for a more direct interpretation of the pass-through of the two monetary policy measures to the interbank money market. Since we control for all periods since the DFR cut, the reference period ranges from the beginning of the sample period (2 January 2017) to the day before the DFR cut (17 September 2019). There were no changes in monetary policy rates and no implementation of any new measure during this reference period.

Figure 4: Estimated effects on pair-wise deal rates after the DFR cut compared to the reference period (before 18 Sep. 2019)



Note: Circles = Estimated coefficients from Table 4. Grey shaded area = 95^{th} confidence band. DFR cut = 18 Sep. 2019; TTS = 30 Oct. 2019; Covid = Period after 9 Mar. 2020; Between = Periods between these events.

Figure 4 visualizes the empirical results for the pair-wise deal rate from Table 4 for the finance groups and the control group, which comprises bilateral secured and unsecured interbank money market transactions outside the two finance groups. When controlling for all observed and unobserved bank-pair heterogeneity, we do not find a statistically significant impact of neither the DFR cut nor the TTS on the lending rate in the non-group interbank money market. However, we do find an effect for the finance groups' internal markets: 8 bps of the 10 bps reduction of the DFR were passed through immediately by head institutes when lending to affiliated banks and 9 bps were passed during the period until the implementation of the TTS. When the TTS was implemented on 30 October

2019, cooperatives and savings banks still borrowed on average at a 7 bps lower rate from their head institutes relative to the reference period. This finding suggests that initially, a part of the pass-through of the DFR cut got offset by the implementation of the TTS. However, this rise in the deal rate was only transitory as indicated by the effect of -11 bps of the period after the implementation of the TTS and before the beginning of the Covid pandemic relative to the reference period. The Covid pandemic itself which, in our sample, spans from March 2020 to December 2020, had the effect of elevating both the intra-group and non-group lending rates. In particular, cooperatives and savings banks borrowed on average at a 6 bps lower rate from their head institutes during the Covid period compared to the reference period, which corresponds to a significant increase in the lending rate compared to the -11 bps during the preceding TTS period. While the two monetary policy measures had no effect on the deal rate in the rest of the interbank market, the Covid period is associated with an increase in the deal rate by, on average, 3 bps.

Our findings suggest that (i) the implementation of the TTS did not cause a permanent increase in interbank lending rates. Only in the finance groups' internal markets it led to a slight increase in the deal rate, which was only of temporary nature though. (ii) Despite the market tensions in the Covid period, after 1.4 years about 59% of the DFR cut was still present in the internal money market of German finance groups, in particular, when considering transactions in which head institutes lend to their affiliated banks.

In Section 4.1, we hypothesized that the TTS caused more active trading within the finance groups' internal markets. Our empirical results confirm that relative to the reference period, cooperatives' and savings banks' daily borrowing volume from their head institutes increased substantially during the periods following the implementation of the TTS. In particular, relative to the reference period, the implementation of the TTS on 30 October 2019 led to an increase in the average intra-group transaction amount by +132%. In the following periods, the effect decreased significantly but it stayed at high levels, with an average effect of +77% during the period following the implementation of the TTS and +38% during the Covid period. We also find positive effects on volumes in the rest of the interbank money market but these effects are considerably smaller and partly not statistically significant. Our findings suggest that finance group members used their internal capital markets to increase their excess reserves or reserve base, aiming to maximize their allowances under the TTS. The lower effect during the Covid period might be connected to the monetary policy measures taken in 2020. In particular, the favourable conditions of the longer-term refinancing operations increased the incentives to participate, also for smaller banks (Deutsche Bundesbank (2020)), making these operations an attractive substitute for intra-group liquidity.

The heterogenous effects of the two monetary policies on the rates and amounts of group and non-group transactions also had an impact on spreads. In particular, due to the stronger pass-through of the DFR cut within internal capital markets, the rate at which cooperatives and savings banks borrowed from their head institutes moved closer to the overall money market rate, i.e. the intra-group spread decreased. This was reinforced by higher intra-group lending volumes, which led to a higher weight of the finance groups in the computation of the composed market rate.

6.3 Robustness

6.3.1 Borrowing dataset

As outlined in Section 4, the MMSR provides two different datasets, one for lending transactions and one for borrowing transactions of the reporting MFIs. Our baseline regressions and descriptive statistics are based on the lending dataset because our focus is on the financing conditions of affiliated banks within internal capital markets and this data set captures lending transactions from head institutes to their affiliated banks. However, we repeat all estimations with the borrowing dataset to check for robustness of our results and to evaluate the net effect of intra-finance group transactions.

We find that all else equal, head institutes borrow on average 126% more at a 9 bps lower spread from their affiliated banks than banks borrowing from the rest of the market. The effect on the spread becomes insignificant when including borrower-time fixed effects. This indicates that head institutes borrow at a competitive spread from their affiliated banks within their internal capital markets. However, in our dataset most cooperatives and savings banks do not lend to their head institutes.

Similar to the lending dataset, we find a significant effect of relationship lending on the pair-wise deal spread for unsecured transactions in the borrowing dataset. A higher number of past transactions as measured by $RL^N_{ij,t}$ in this market segment is associated with a lower spread. A higher volume of past transactions as measured by $RL^V_{ij,t}$ is associated with a higher spread (see Table 8). Regarding the role of relationship lending within finance groups' internal capital markets, the borrowing dataset provides a result that is very similar the lending dataset: Unlike in the rest of the unsecured market, in internal capital markets, a higher number of past transactions $RL^N_{ij,t}$ is not associated with a statistically significant reduction in the spread. However, unlike in the lending dataset $RL^V_{ij,t}$ is associated with a higher spread within internal capital markets but the effect is only half as large as in the rest of the market.

The monetary policy effects of our baseline regressions are also broadly robust when using the borrowing dataset. In particular, we also find a statistically highly significant immediate pass-through of the 10 bps reduction in the DFR in internal markets. The immediate pass-through is even larger than in the baseline regressions (see first column in Table 10). In addition, the pass-through of the DFR cut within the finance groups' internal markets is more permanent with an average pass-through of 92 % even during the Covid period (compared to 57 % in our baseline regressions). In contrast to our baseline regressions, we also find an immediate pass-through of the DFR cut outside of groups' internal markets. However, this pass-through is relatively small (around -3 bps) and further decreases after the implementation of the TTS. A further difference to our baseline regression results is that we do not find a significant effect of the TTS on the pair-wise amount, neither within nor outside finance groups' internal markets. Altogether, our findings suggest that affiliated banks borrowed substantially more following the start of the TTS but did not deposit those funds on their accounts with their head institutes. This suggests that our findings are driven by the savings banks and the cooperatives fulfilling their minimum reserve requirement individually (see Figure 3).

6.3.2 Further robustness analyses using the lending dataset

We perform several further robustness analyses shown in Section A.5. We restrict our estimation sample to the pre-TTS-period and to overnight transactions, respectively. When restricting the sample to the pre-TTS period, the effect of the main variable of interest, $Group_{ij}$, on the pair-wise deal spread stays broadly unchanged compared to the benchmark estimation. The coefficients of the other independent variables stay also robust (see columns 1 and 2 in Table 6 and columns 2 and 4 in Table 1). The same holds when restricting the sample to overnight transactions (columns 3 and 4 in Table 6). The results regarding the effects on loan volume are also widely robust but the effect of the group dummy when only looking at overnight transactions is significantly lower than in the benchmark estimation when including lender-month fixed effects (compare column 7 in Table 6 to column 6 in Table 1).

In the relationship lending regressions (for the unsecured segment), we substitute the broad relationship lending variables with borrower and lender preference indices in order to check for robustness. The lender preference index measures how strongly a lender's lending is concentrated at a given borrower. Analogously, the borrower preference index measures how strongly a borrower's borrowing is concentrated at a given lender. We calculate the indices both based on the number of past transactions ($LPI^N_{ij,t}$ and $BPI^N_{ij,t}$) and based on the volume of these transactions ($LPI^V_{ij,t}$ and $BPI^V_{ij,t}$) respectively (see Section 5.1.2 for the exact formulas).[22]

The results of our robustness analyses are displayed in Table 5. The lender preference index based on volumes has no significant impact on neither spreads nor volumes. However, we find a positive and statistically highly significant coefficient of $BPI^V_{ij,t}$ on the pair-wise spread. This finding suggests that an increase in the concentration of bank's borrowing volume at a given lender is associated with a higher spread. For our benchmark result, this finding implies that a higher past lending volume between a bank pair as measured by $RL^V_{ij,t}$ is associated with a higher spread because of a bank's borrowing concentration rather than a bank's lending concentration. A potential reason for this could be that lenders charge a higher spread by using their relative market power when a borrower is relatively more dependent on them. Our findings are similar to Bräuning and Fecht (2017). The authors also find a positive relationship between the (non-normalized) volume-based BPI and the deal spread during the financial crisis.[23] Temizsoy et al. (2015) find a positive but not significant relationship between the (normalized) volume-based BPI during the crisis.

In the regressions with the pair-wise amount as the dependent variable $BPI^V_{ij,t}$ also has a positive and significant effect both within finance groups' internal markets and in the rest of the interbank market. This result is in line with the literature (see for instance Temizsoy et al. (2015)) and consistent with the results from our baseline regression in Table 1. A stronger relationship indicated by both $LPI^N_{ij,t}$ and $BPI^N_{ij,t}$ is also associated with larger amounts.

[22] As outlined in Section 5.1.2, an important caveat of using the BPI in our framework is that if a bank has borrowed from only one bank during the previous 30 days, $BPI^V_{ij,t}$ and $BPI^N_{ij,t}$ will be equal to one by definition even though the bank's borrowing concentration is at a maximum. This complicates a meaningful interpretation of the coefficient of BPI variables for the finance groups since their members often trade with only one head institute.

[23] However, their result is not significant in the most robust specification of their model.

7 Concluding remarks

This paper sheds light on the functioning of internal capital markets by comparing bilateral spreads and volumes for transactions within the German savings banks and cooperatives finance groups to transactions outside these groups. We find that the functioning of internal capital markets diverges substantially from the non-group interbank money market. Head institutes lend larger amounts at lower spreads to their affiliated banks than to banks outside their internal capital markets. The lower spread might reflect lower credit risk and search costs as well as regulatory privileges of intra-group transactions. While in general relationship lending is associated with lower spreads in the unsecured market, this is not the case within internal capital markets. This finding indicates that counterparty credit risk and information asymmetries are less relevant within internal capital markets. We find an almost full immediate pass-through of the reduction of the deposit facility rate in 2019 to internal capital markets, in contrast to the rest of the interbank money market. The introduction of the two-tier system led to a slight transitory increase in rates and to a persistent increase in loan volumes within internal capital markets but not in the rest of the interbank money market.

Our findings imply that internal capital markets could have an impact on banks' lending to the real economy. For instance, the ample provision of liquidity and the lack of search costs within internal capital markets likely imply favorable short-term funding conditions for affiliated banks, probably also when the money market is tight. This should have a positive impact on cooperatives' and savings banks' lending to the non-financial sector. The same holds for the heterogeneous pass-through of monetary policy: A stronger pass-through of monetary policy measures to internal capital markets could also imply that affiliated banks adjust their lending rates faster than banks that are not part of an internal capital market. Therefore, further research could focus on how the diverging loan pricing within internal capital markets outlined in this paper affects lending to the non-financial private sector.

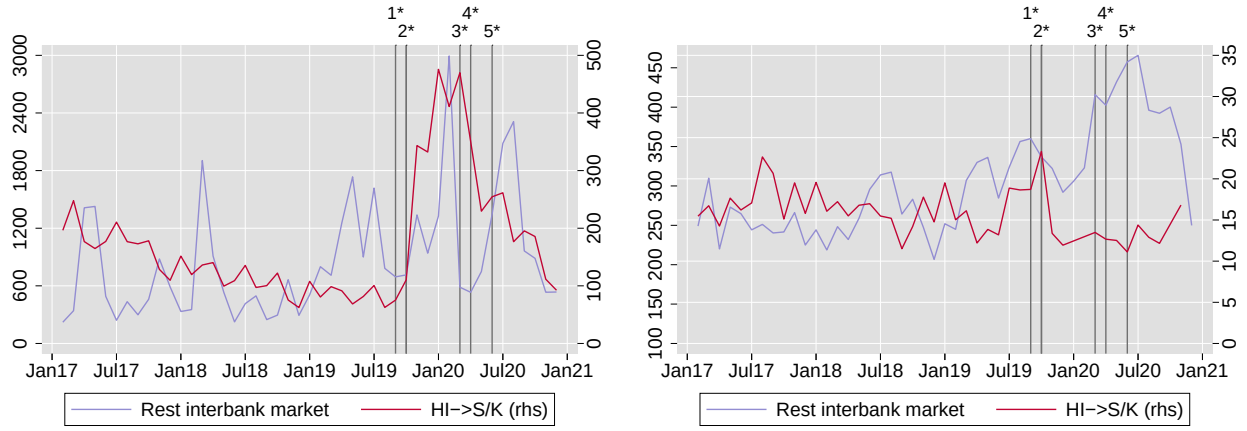
A Appendix

A.1 Definition of variables

Formula	Definition
Dependent variables	
$Spread_{ij,t} = \frac{\sum_{n=1}^{N_{ij,t}}(r_{ij,t,n} \times v_{ij,t,n})}{\sum_{n=1}^{N_{ij,t}} v_{ij,t,n}} - \bar{r}_t$	The spread between the volume-weighted average interest rate of bank pair ij on day t and the volume-weighted average market interest rate on the same day.
$Amount_{ij,t} = \log(\sum_{n=1}^{N_{ij,t}} v_{ij,t,n})$	The logarithm of the transaction volume of bank pair ij on day t.
Independent variables	
$RL^V_{ij,t} = log(1 + \sum_{s=1}^{30} V_{ij,t-s})$	Logarithm of 1 + the overall transaction volume between bank pair ij during the 30 days prior to day t.
$RL^N_{ij,t} = log(1 + \sum_{s=1}^{30} N_{ij,t-s})$	Logarithm of 1 + the number of trades between bank pair ij during the 30 days prior to day t.
$LPI^V_{ij,t} = \frac{\sum_{s=1}^{30} V_{ij,t-s}}{\sum_j \sum_{s=1}^{30} V_{ij,t-s}/outdegree^{30}_{i,t}}$	The ratio of the amount bank i lent to bank j during the 30 days prior to day t to the average amount that i lent to its borrowers during the 30 days prior to day t.
$BPI^V_{ij,t} = \frac{\sum_{s=1}^{30} V_{ij,t-s}}{\sum_i \sum_{s=1}^{30} V_{ij,t-s}/indegree^{30}_{j,t}}$	The ratio of the amount bank j borrowed from bank i during the 30 days prior to day t to the average amount that j borrowed from its lenders during the 30 days prior to day t.
$LPI^N_{ij,t} = \frac{\sum_{s=1}^{30} N_{ij,t-s}}{\sum_j \sum_{s=1}^{30} N_{ij,t-s}/outdegree^{30}_{i,t}}$	The ratio of the number of loans bank i lent to bank j during the 30 days prior to day t to the average number of loans i lent to its borrowers during the 30 days prior to day t.
$BPI^N_{ij,t} = \frac{\sum_{s=1}^{30} N_{ij,t-s}}{\sum_i \sum_{s=1}^{30} N_{ij,t-s}/indegree^{30}_{j,t}}$	The ratio of the number of loans bank j borrowed from bank i during the 30 days prior to day t to the average number of loans j borrowed from its lenders during the 30 days prior to day t.
$Volume_{ij,t} = \frac{V_{ij,t}}{\sum_i \sum_j V_{ij,t}}$	Amount traded between bank pair ij on day t in relation to the total amount traded on that day.
$Transactions_{ij,t} = \frac{N_{ij,t}}{\sum_i \sum_j N_{ij,t}}$	Number of loans between bank pair ij on day t in relation to all loans on that day.
$Maturity_{ij,t} = log(\frac{\sum_{n=1}^{N_{ij,t}}(v_{ij,t,n} \times maturity_{ij,t,n})}{V_{ij,t}})$	Logarithm of the volume-weighted average maturity for bank pair ij on day t.
$Outdegree_{i,t} = \frac{outdegree_{ij,t}}{J_t}$	Number of borrowers of lender i on day t in relation to total number of borrowers J on that day.
$Indegree_{j,t} = \frac{indegree_{ij,t}}{I_t}$	Number of lenders of borrower j on day t in relation to total number of lenders I on that day.
$Fixed_{ij,t} = \frac{N^{fixed}_{ij,t}}{N_{ij,t}}$	Number of loans with fixed rate between bank pair ij relative to all loans between bank pair ij on day t.

A.2 Descriptive figures

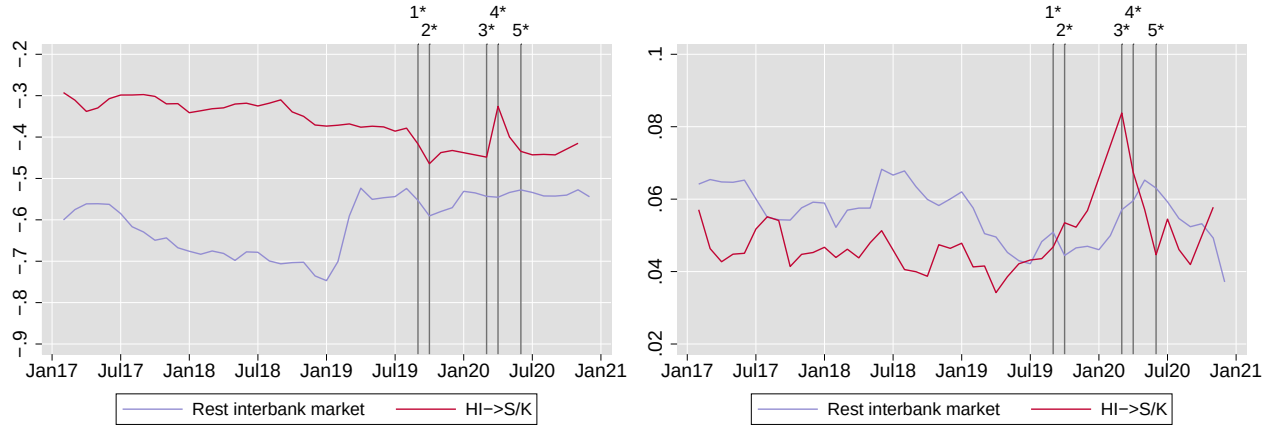
Figure 5: Total monthly transaction volumes



(a) Lending (b) Borrowing

Note: In €bn. *[1= Deposit facility rate decreased by 10 bps to -0.5% on 18 Sep. 2019. 2= Two-tier system for reserve remuneration implemented in the Eurosystem on 30 Oct. 2019. 3= Covid crisis intensified in Mar. 2020. 4= ECB Governing Council on 30 Apr. 2020; TLTRO-III conditions were eased. 5= ECB Governing Council on 4 Jun. 2020; PEPP expansion by € 600 bn.] HI = Head Institutes. K = Cooperatives. S = Savings banks.
Source: Deutsche Bundesbank, Money market statistical reporting.

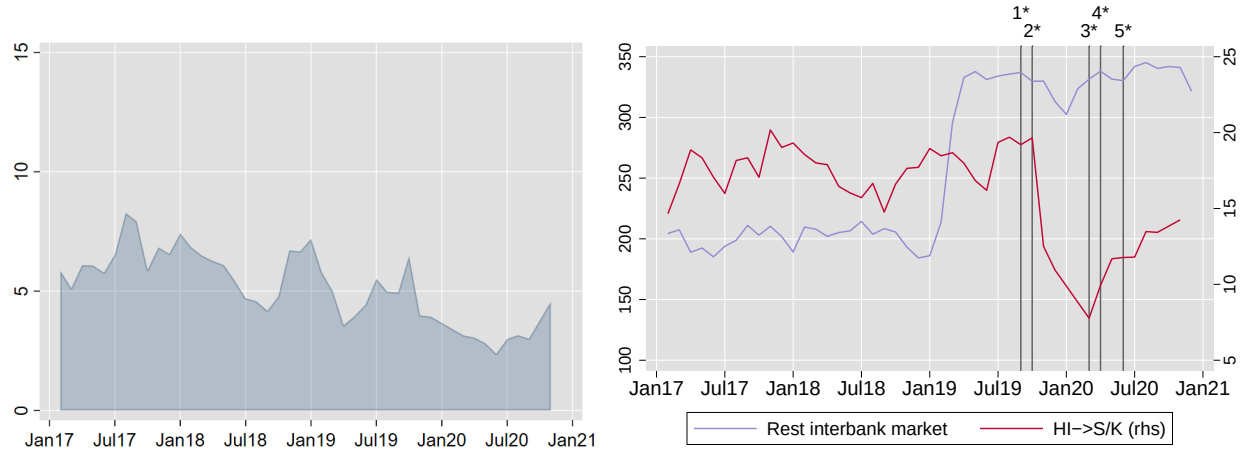
Figure 6: Average monthly^{+} pair-wise deal rate and volume (MMSR - borrowing dataset)



(a) Rate (b) Volume

Note: In percentage (a). In €bn (b). $^{+}$For reasons of confidentiality, only monthly data are shown. *[1= Deposit facility rate decreased by 10 bps to -0.5% on 18 Sep. 2019. 2= Two-tier system for reserve remuneration implemented in the Eurosystem on 30 Oct. 2019. 3= Covid crisis intensified in Mar. 2020. 4= ECB Governing Council on 30 Apr. 2020; TLTRO-III conditions were eased. 5= ECB Governing Council on 4 Jun. 2020; PEPP expansion by € 600 bn.] HI = Head institutes. K = Cooperatives. S = Savings banks.
Source: Deutsche Bundesbank, Money market statistical reporting.

Figure 7: Importance of finance groups in the interbank money market (MMSR - borrowing dataset)



(a) Groups' share on total monthly volumes

(b) Average monthly number of bank pairs

Note: In percentage (a). *[1= Deposit facility rate decreased by 10 bps to -0.5% on 18 Sep. 2019. 2= Two-tier system for reserve remuneration implemented in the Eurosystem on 30 Oct. 2019. 3= Covid crisis intensified in Mar. 2020. 4= ECB Governing Council on 30 Apr. 2020; TLTRO-III conditions were eased. 5= ECB Governing Council on 4 Jun. 2020; PEPP expansion by € 600 bn.] HI = Head institutes. K = Cooperatives. S = Savings banks.
Source: Deutsche Bundesbank, Money market statistical reporting.

A.3 Characteristics of the estimation samples

	HI lends to S/K		HI borrows from S/K	
	MEAN	SD	MEAN	SD
Deal spread$_{ij,t}$ *(bp)*				
Intra-finance group	4.12	8.86	21.07	13.61
Rest interbank market	-35.73	49.20	-0.01	41.63
Deal rate$_{ij,t}$ *(in %)*				
Intra-finance group	-0.31	0.09	-0.36	0.12
Rest interbank market	-0.70	0.49	-0.59	0.40
Amount$_{ij,t}$ *(in €mn)*				
Intra-finance group	30.62	41.30	47.64	64.51
Rest interbank market	196.21	3106.50	54.67	156.58
Maturity$_{ij,t}$ *(days)*				
Intra-finance group	7.01	23.11	-*	127.25
Rest interbank market	16.17	51.05	13.80	44.18
Fixed$_{ij,t}$ *(in %)*				
Intra-finance group	93.87	23.59	99.25	8.65
Rest interbank market	90.68	28.68	93.79	23.85
Outdegree$^{**}_{i,t}$ *(# borrowers)*				
Intra-finance group	99.99	63.73	1.04	0.22
Rest interbank market	41.09	40.74	2.82	2.17
Indegree$^{**}_{j,t}$ *(# lenders)*				
Intra-finance group	1.26	0.60	25.49	11.80
Rest interbank market	3.26	2.33	25.31	16.23
RL$^{V}_{ij,t}$ *(in €mn)*				
Intra-finance group	553.70	783.01	773.64	1028.51
Rest interbank market	3336.02	43601.19	966.95	2231.93
RL$^{N}_{ij,t}$ *(# loans)*				
Intra-finance group	22.80	36.57	18.62	13.78
Rest interbank market	124.63	338.74	190.81	536.39
LPI$^{V}_{ij,t}$				
Intra-finance group	1.09	1.44	1.05	0.29
Rest interbank market	1.61	4.57	1.11	0.99
LPI$^{N}_{ij,t}$				
Intra-finance group	0.87	0.85	1.03	0.22
Rest interbank market	2.15	4.49	1.18	1.22
BPI$^{V}_{ij,t}$				
Intra-finance group	1.03	0.32	1.88	2.49
Rest interbank market	1.10	1.13	1.20	2.11
BPI$^{N}_{ij,t}$				
Intra-finance group	1.03	0.26	0.67	0.64
Rest interbank market	1.14	0.81	1.42	1.93

*Is not shown due to confidentiality. ** not normalized. HI = Head institutes. K = Cooperatives. S = Savings banks.

A.4 Baseline regression results - head institute lends to savings bank /cooperative

Table 1

	Dependent variable:							
VARIABLES	**Pair-wise spread**				**Pair-wise amount**			
Group_{ij}	-0.045***	-0.038**	0.045***	0.073***	0.429***	0.627***	-0.158	0.028
$\text{Volume}_{ij,t}$	1.437***	1.411***	1.193***	1.030***				
$\text{Transactions}_{ij,t}$	-0.661	-0.961	-1.229	-1.427	55.899***	52.358***	96.982***	91.379***
$\text{Maturity}_{ij,t}$	0.062***	0.067***	0.064***	0.072***	0.242***	0.256***	0.373***	0.410***
$\text{Fixed}_{ij,t}$	-0.207***	-0.273***	-0.230***	-0.277***	-0.138	0.010	0.140	-0.058
$\text{Outdegree}_{i,t}$	0.390***	0.071**	-0.024	0.019*	-2.568***	1.711***	-0.223	1.844***
$\text{Indegree}_{j,t}$	-0.150	-0.166	-0.006	-0.051	2.798***	1.799***	0.098	0.033
$\text{RL}^N_{ij,t}$	-0.089***	-0.080***	-0.055***	-0.038***	-0.415***	-0.324***	0.102***	0.154***
$\text{RL}^V_{ij,t}$	0.023***	0.025***	0.016***	0.013***	0.330***	0.286***	0.086***	0.069***
Observations	468,526	468,491	467,622	467,607	468,526	468,491	467,622	467,607
$[Lender * month]$ f.e.	no	yes	no	yes	no	yes	no	yes
$[Borrower * month]$ f.e.	no	no	yes	yes	no	no	yes	yes
Day f.e.	yes	yes	yes	yes	yes	yes	yes	yes
Market f.e.	yes	yes	yes	yes	yes	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Errors clustered at the bank-pair level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. Markets: Unsecured and bilateral secured interbank money market. Group_{ij} equals one if the trade is between a head institute and a savings bank or a cooperative and zero if otherwise.

Table 2: Importance of relationship lending

	Dependent variable: Pair-wise spread						
VARIABLES	**Unsecured market**					**Secured market**	
$RL^N_{ij,t}$	-0.056***	-0.461***				0.007***	0.006
$RL^V_{ij,t}$	0.029***	0.019***				-0.001***	-0.001***
$RL^N_{ij,t}$*$RL^V_{ij,t}$		0.019***					0.000
$nonGroup_{ij}$* $RL^N_{ij,t}$			-0.109***	-0.073***	-0.057***		
$Group_{ij}$*$RL^N_{ij,t}$			0.059**	-0.016	0.033		
$nonGroup_{ij}$*$RL^V_{ij,t}$			0.051***	0.033***	0.030***		
$Group_{ij}$*$RL^V_{ij,t}$			-0.007*	0.002	-0.001		
Observations	148,890	148,890	149,392	148,904	148,890	318,495	318,495
$[Lender * month]$ f.e.	yes	yes	yes	no	yes	yes	yes
$[Borrower * month]$ f.e.	yes	yes	no	yes	yes	yes	yes
Day f.e.	yes	yes	yes	yes	yes	yes	yes
Pair controls	yes	yes	yes	yes	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Errors clustered at the bank-pair level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. $Group_{ij}$ equals one if the trade is between a head institute and a savings bank or a cooperative and zero if otherwise. $nonGroup_{ij}$ equals one if the trade is outside the cooperatives or savings banks banking sector and zero if otherwise.

Table 3: Importance of relationship lending

	Dependent variable: Pair-wise amount						
VARIABLES	**Unsecured market**					**Secured market**	
$RL^N_{ij,t}$	0.186***	-2.523***				0.118***	-2.495***
$RL^V_{ij,t}$	0.149***	0.058***				0.007***	0.038***
$RL^N_{ij,t}$*$RL^V_{ij,t}$		0.130***					0.122***
$nonGroup_{ij}$* $RL^N_{ij,t}$			0.019	0.123***	0.182***		
$Group_{ij}$*$RL^N_{ij,t}$			0.629***	0.570***	0.855***		
$nonGroup_{ij}$*$RL^V_{ij,t}$			0.284***	0.184***	0.151***		
$Group_{ij}$*$RL^V_{ij,t}$			-0.070***	-0.045***	-0.084***		
Observations	148,890	148,890	149,392	148,904	148,890	318,495	318,495
$[Lender * month]$ f.e.	yes	yes	yes	no	yes	yes	yes
$[Borrower * month]$ f.e.	yes	yes	no	yes	yes	yes	yes
Day f.e.	yes	yes	yes	yes	yes	yes	yes
Pair controls	yes	yes	yes	yes	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Errors clustered at the bank-pair level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. $Group_{ij}$ equals one if the trade is between a head institute and a savings bank or a cooperative and zero if otherwise. $nonGroup_{ij}$ equals one if the trade is outside the cooperatives or savings banks banking sector and zero if otherwise.

A.4.1 Monetary policy transmission

Table 4

VARIABLES	Dependent variable:		
	Pair-wise rate	**Pair-wise spread**	**Pair-wise amount**
nonGroup_{ij}*D^{DFR}	0.007	0.041***	0.108***
Group_{ij}*D^{DFR}	-0.082***	-0.052***	0.064*
nonGroup_{ij}*$\text{D}^{18Sep<d<30Oct}$	-0.004	0.039**	-0.004
Group_{ij}*$\text{D}^{18Sep<d<30Oct}$	-0.092***	-0.052***	-0.014
nonGroup_{ij}*D^{TTS}	0.015	0.087***	0.190***
Group_{ij}*D^{TTS}	-0.068***	0.008	0.840***
nonGroup_{ij}*D^{TTS2}	0.008	0.100***	0.108*
Group_{ij}*D^{TTS2}	-0.107***	-0.008	0.570***
nonGroup_{ij}*D^{Covid}	0.030*	0.104***	0.067
Group_{ij}*D^{Covid}	-0.057***	0.020***	0.324***
Observations	468,376	468,376	468,376
$[Lender * borrower]$ f.e.	yes	yes	yes
Day f.e.	no	no	no
Market f.e.	yes	yes	yes
Pair controls	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Errors clustered at the bank-pair and daily level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. Markets: Unsecured and bilateral secured interbank money market. D^{DFR} equals one for 18 Sep. 2019 (DFR decreased by 10 bps to -0.5%) and zero otherwise. $\text{D}^{18Sep<d<30Oct}$ equals one for the period from 19 Sep. until 29 Oct. 2019 and zero otherwise. D^{TTS} equals one for 30 Oct. 2019 (ECB implemented the two-tier system for reserve remuneration) and zero otherwise. D^{TTS2} equals one for the period from 31 Oct. 2019 until 9 Mar. 2020 and zero otherwise. D^{Covid} equals one for the period after 9 Mar. 2020 and zero otherwise. Group_{ij} equals one if the trade is between a head institute and a savings bank or a cooperative and zero if otherwise. nonGroup_{ij} equals one if the trade is outside the cooperatives or savings banks banking sector and zero if otherwise.

A.5 Robustness

Table 5: Importance of relationship lending in the unsecured interbank money market

	Dependent variable:			
VARIABLES	**Pair-wise spread**		**Pair-wise amount**	
nonGroup_{ij}*$\text{LPI}^V_{ij,t}$	0.000		0.020*	
nonGroup_{ij}*$\text{BPI}^V_{ij,t}$	0.074***		0.513***	
Group_{ij}*$\text{LPI}^V_{ij,t}$	-0.052		-0.078	
Group_{ij}*$\text{BPI}^V_{ij,t}$	0.128***		0.928***	
nonGroup_{ij}*$\text{LPI}^N_{ij,t}$		0.002		0.013
nonGroup_{ij}*$\text{BPI}^N_{ij,t}$		-0.002		0.417***
Group_{ij}*$\text{LPI}^N_{ij,t}$		0.044**		0.857***
Group_{ij}*$\text{BPI}^N_{ij,t}$		0.042*		-0.262
Observations	147,997	147,997	147,997	147,997
$[Lender * month]$ f.e.	yes	yes	yes	yes
$[Borrower * month]$ f.e.	yes	yes	yes	yes
Day f.e.	yes	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Errors clustered at the bank-pair level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. Group_{ij} equals one if the trade is between a head institute and a savings bank or cooperative and zero if otherwise.nonGroup_{ij} equals one if the trade is outside the cooperatives or savings banks banking sector and zero if otherwise.

Table 6

	Dependent variable:							
	Pair-wise spread				Pair-wise amount			
VARIABLES	**Pre-TTS**		**o/n**		**Pre-TTS**		**o/n**	
Group_{ij}	-0.043**	0.064**	-0.036***	0.062**	0.581***	-0.105	0.202**	-0.062
$\text{Volume}_{ij,t}$	1.658***	1.182***	1.275***	0.872***				
$\text{Transactions}_{ij,t}$	0.037	-0.720	-1.977*	-1.121	44.425***	90.034***	44.065***	92.792***
$\text{Maturity}_{ij,t}$	0.055***	0.062***	0.108***	0.105***	0.248***	0.409***	0.489***	0.535***
$\text{Fixed}_{ij,t}$	-0.339***	-0.341***	-0.529***	-0.519***	0.060	-0.046	-0.226	-0.675**
$\text{Outdegree}_{i,t}$	0.033	0.013	0.061**	0.003	1.862***	1.823***	1.879***	1.674***
$\text{Indegree}_{j,t}$	-0.375**	-0.098*	-0.106	-0.027	1.677***	0.203	2.387***	-0.201
$\text{RL}^{N}_{ij,t}$	-0.082***	-0.044***	-0.062***	-0.024***	-0.260***	0.177***	-0.166**	0.288***
$\text{RL}^{V}_{ij,t}$	0.023***	0.013***	0.022***	0.012***	0.262***	0.066***	0.305***	0.055***
Observations	301,282	300,677	391,208	390,901	301,282	300,677	391,208	390,901
$[Lender * month]$ f.e.	yes	yes	yes	yes	yes	yes	yes	yes
$[Borrower * month]$ f.e.	no	yes	no	yes	no	yes	no	yes
Day f.e.	yes	yes	yes	yes	yes	yes	yes	yes
Market f.e.	yes	yes	yes	yes	yes	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Estimations based on the benchmark regression model (see Equation 8). Errors clustered at the bank-pair level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. Markets: Unsecured and bilateral secured interbank money market. Group_{ij} equals one if the trade is between a head institute and a savings bank or cooperative and zero if otherwise. Pre-TTS = Period before the implementation of the two-tier-system by the Eurosystem on 30 October 2019.

A.5.1 Regression results - head institute borrows from savings bank / cooperative

Table 7

	Dependent variable:							
VARIABLES	Pair-wise spread				Pair-wise amount			
Group_{ij}	-0.088***	-0.149***	0.010	0.023	0.816***	-0.120***	0.461***	0.553*
$\text{Volume}_{ij,t}$	4.973***	5.365***	5.092***	5.705***				
$\text{Transactions}_{ij,t}$	-2.402**	1.306	-0.323	1.124	85.319***	2.755***	64.310***	31.684***
$\text{Maturity}_{ij,t}$	0.042***	0.045***	0.054***	0.045***	0.275***	0.056***	0.236***	0.500***
$\text{Fixed}_{ij,t}$	-0.242***	-0.257***	-0.064	-0.120**	0.222	-0.288***	-0.110	-0.035
$\text{Outdegree}_{i,t}$	-0.440**	0.076	-0.289*	0.059	2.426***	0.079	1.950***	1.772***
$\text{Indegree}_{j,t}$	-0.148	-0.180	0.010	0.010	-1.101*	-0.191	3.266***	0.973***
$\text{RL}^N_{ij,t}$	0.017**	-0.025***	-0.002	-0.016	-0.701***	-0.025***	-0.402***	0.425***
$\text{RL}^V_{ij,t}$	-0.009***	0.011***	0.007***	0.009***	0.610***	0.012***	0.449***	0.063***
Observations	276,278	275,882	276,211	275,832	276,278	275,882	276,211	275,832
$[Lender * month]$ f.e.	no	yes	no	yes	no	yes	no	yes
$[Borrower * month]$ f.e.	no	no	yes	yes	no	no	yes	yes
Day f.e.	yes	yes	yes	yes	yes	yes	yes	yes
Market f.e.	yes	yes	yes	yes	yes	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Errors clustered at the bank-pair level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. Markets: Unsecured and bilateral secured interbank money market. Group_{ij} equals one if the trade is between a head institute and a savings bank or cooperative and zero if otherwise.

Table 8: Importance of relationship lending

	Dependent variable: Pair-wise spread						
VARIABLES	**Unsecured market**					**Secured market**	
$RL^N_{ij,t}$	-0.030**	-0.418***				0.007**	-0.012***
$RL^V_{ij,t}$	0.018***	0.013***				-0.000*	-0.000
$RL^N_{ij,t}$*$RL^V_{ij,t}$		0.018***					0.001***
$nonGroup_{ij}$* $RL^N_{ij,t}$			-0.037***	-0.048***	-0.030**		
$Group_{ij}$*$RL^N_{ij,t}$			0.002	0.037	0.004		
$nonGroup_{ij}$*$RL^V_{ij,t}$			0.020***	0.032***	0.018***		
$Group_{ij}$*$RL^V_{ij,t}$			0.011***	0.006***	0.009***		
Observations	158,485	158,485	158,547	158,649	158,485	117,198	117,198
$[Lender * month]$ f.e.	yes	yes	yes	no	yes	yes	yes
$[Borrower * month]$ f.e.	yes	yes	no	yes	yes	yes	yes
Day f.e.	yes	yes	yes	yes	yes	yes	yes
Pair controls	yes	yes	yes	yes	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Errors clustered at the bank-pair level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. $Group_{ij}$ equals one if the trade is between a head institute and a savings bank or a cooperative and zero if otherwise. $nonGroup_{ij}$ equals one if the trade is outside the cooperatives or savings banks banking sector and zero if otherwise.

Table 9: Importance of relationship lending

	Dependent variable: Pair-wise amount						
VARIABLES	**Unsecured market**					**Secured market**	
$RL^N_{ij,t}$	0.363***	-3.759***				0.056***	-0.814***
$RL^V_{ij,t}$	0.145***	0.063***				0.001	0.007***
$RL^N_{ij,t}$*$RL^V_{ij,t}$		0.191***					0.043***
$nonGroup_{ij}$* $RL^N_{ij,t}$			0.317***	0.060	0.363***		
$Group_{ij}$*$RL^N_{ij,t}$			0.014	-0.199	0.043		
$nonGroup_{ij}$*$RL^V_{ij,t}$			0.181***	0.370***	0.145***		
$Group_{ij}$*$RL^V_{ij,t}$			0.117***	0.145***	0.111***		
Observations	158,485	158,485	158,547	158,649	158,485	117,198	117,198
$[Lender * month]$ f.e.	yes	yes	yes	no	yes	yes	yes
$[Borrower * month]$ f.e.	yes	yes	no	yes	yes	yes	yes
Day f.e.	yes	yes	yes	yes	yes	yes	yes
Pair controls	yes	yes	yes	yes	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Errors clustered at the bank-pair level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. $Group_{ij}$ equals one if the trade is between a head institute and a savings bank or a cooperative and zero if otherwise. $nonGroup_{ij}$ equals one if the trade is outside the cooperatives or savings banks banking sector and zero if otherwise.

Table 10

VARIABLES	Dependent variable:		
	Pair-wise rate	**Pair-wise spread**	**Pair-wise amount**
nonGroup_{ij}*D^{DFR}	-0.031***	-0.002	-0.047
Group_{ij}*D^{DFR}	-0.093***	-0.064***	0.131
nonGroup_{ij}*$\text{D}^{18Sep<d<30Oct}$	-0.038***	0.006	-0.111**
Group_{ij}*$\text{D}^{18Sep<d<30Oct}$	-0.099***	-0.055***	0.196**
nonGroup_{ij}*D^{TTS}	-0.032***	0.081***	-0.085*
Group_{ij}*D^{TTS}	-0.099***	0.016***	0.144
nonGroup_{ij}*D^{TTS2}	-0.024**	0.089***	-0.065
Group_{ij}*D^{TTS2}	-0.098***	0.018**	-0.006
nonGroup_{ij}*D^{Covid}	-0.020*	0.140***	-0.121**
Group_{ij}*D^{Covid}	-0.092***	0.089***	0.016
Observations	276,125	276,125	276,125
$[Lender * borrower]$ f.e.	yes	yes	yes
Day f.e.	no	no	no
Pair controls	yes	yes	yes

(*** p<0.01; ** p<0.05; * p<0.1) Errors clustered at the bank-pair and daily level. A constant is included in each model. Estimation period: 2 January 2017 - 30 December 2020. Markets: Unsecured and bilateral secured interbank money market. D^{DFR} equals one for 18 Sep. 2019 (DFR decreased by 10 bps to -0.5%) and zero otherwise. $\text{D}^{18Sep<d<30Oct}$ equals one for the period from 19 Sep. until 29 Oct. 2019 and zero otherwise. D^{TTS} equals one for 30 Oct. 2019 (ECB implemented the two-tier system for reserve remuneration) and zero otherwise. D^{TTS2} equals one for the period from 31 Oct. 2019 until 9 Mar. 2020 and zero otherwise. D^{Covid} equals one for the period after 9 Mar. 2020 and zero otherwise. Group_{ij} equals one if the trade is between a head institute and a savings bank or a cooperative, and zero if otherwise. nonGroup_{ij} equals one if the trade is outside the savings bank or cooperative banking sector and zero if otherwise.

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