DEUTSCHE BUNDESBANK
EUROSYSTEM

Discussion Paper

Deutsche Bundesbank
No 31/2017

Bargaining power and outside options in the interbank lending market

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Internet http://www.bundesbank.de

ISBN 978–3–95729–402–9 (Printversion)
ISBN 978–3–95729–403–6 (Internetversion)

Non-technical Summary

Research Question

Many central banks maintain a close relationship between the supply of reserve balances and an average short-term interest rate (i.e., the overnight interbank rate). In this paper, we ask how reliable an average effective overnight interbank rate is to maintain this relationship.

Contribution

We contribute to the literature by showing that that the interest rates in the interbank market may vary strongly across market participants depending on different outside options and especially bilateral bargaining power of both the lender and the borrower of a given trade. Moreover, we show that variation in bilateral bargaining power can induce both arbitrage opportunities and segmentation of prices in interbank markets.

Results

We find that (i) lenders with greater bargaining power than their borrowers are able to negotiate higher interest rates, (ii) lenders with access to the deposit facility of the European Central Bank charge higher interest rates for overnight loans than their peers without such an access, (iii) the negotiated interest rates are more sensitive to the bargaining power of the lender bank if the lending institution has no access to the deposit facility, and (iv) interest rates can fall below the Eurosystem's rate paid on excess reserves (IOER) if the bargaining power of the lender is sufficiently small and the lender has no outside options. Arbitrage opportunities can only arise when these banks persistently provide funds at a rate below the IOER rate, inducing a segmentation of prices for central bank reserves in the euro interbank market. In result, some banks face substantially different refinancing cost than suggested by the official average effective overnight rate, thereby affecting the transmission of monetary policy.

NICHTTECHNISCHE ZUSAMMENFASSUNG

FORSCHUNGSFRAGE

Viele Zentralbanken unterstellen einen engen Zusammenhang zwischen der am Markt bereitgestellten Liquiditätsmenge und dem durchschnittlichen kurzfristigen Zinssatz (gemessen durch die Interbankenrate). In diesem Papier untersuchen wir die Frage, wie zuverlässig ein durchschnittlicher Effektivzinssatz für Interbankenkredite diesen Zusammenhang abbildet.

BEITRAG

Wir tragen zur Literatur bei, indem wir zeigen, dass die tatsächlichen Zinssätze für Übernachtkredite im Interbankenmarkt für verschiedene Marktteilnehmer sehr unterschiedlich sein können und dabei insbesondere von den Alternativoptionen sowie der jeweiligen Verhandlungsmacht des Kreditgebers und des Kreditnehmers abhängen. Darüber hinaus erläutern wir, dass die Unterschiedlichkeit der bilateralen Verhandlungspositionen sowohl zu Arbitragemöglichkeiten als auch zu einer Segmentierung im Interbankenmarkt führen kann.

ERGEBNISSE

Unsere Ergebnisse zeigen, dass (i) Kreditgeber, die eine größere Verhandlungsmacht als ihre Kreditnehmer haben, höhere Zinssätze erzielen können, (ii) Kreditgeber mit Zugang zu der Einlagefazilität der Europäischen Zentralbank höhere Zinssätze erhalten als solche, die nicht über einen entsprechenden Zugang verfügen, (iii) die verhandelten Zinssätze stärker von der Verhandlungsmacht des Kreditgebers abhängen, wenn dieser keinen Zugang zu der Einlagefazilität hat, (iv) der verhandelte Zinssatz unterhalb des Zinssatzes der Einlagefazilität liegen kann, wenn die Verhandlungsmacht des Kreditgebers hinreichend klein ist und er keinen Zugang zu der Einlagefazilität hat. Arbitragemöglichkeiten können dann entstehen, wenn im letztgenannten Fall Gelder über einen längeren Zeitraum unterhalb dieses Einlagesatzes bereitgestellt werden und somit eine Segmentierung der Preise für Zentralbankgeld im Interbankenmarkt zu beobachten ist. Dadurch sehen sich manche Banken mit deutlich anderen Refinanzierungskosten konfrontiert, als durch einen durchschnittlichen Effektivzinssatz für Interbankenkredite suggeriert wird, was unter Umständen die Transmission geldpolitischer Maßnahmen beeinträchtigen kann.

Bundesbank Discussion Paper No 31/2017

BARGAINING POWER AND OUTSIDE OPTIONS IN THE INTERBANK LENDING MARKET*

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ABSTRACT

We study the role of bargaining power and outside options for the pricing of over-the-counter interbank loans using a bilateral Nash bargaining model and test the model predictions with detailed transaction-level data from the euro-area interbank market. We find that lender banks with greater bargaining power over their borrowers charge higher interest rates, while the lack of alternative investment opportunities for lenders reduces bilateral interest rates. Moreover, we find that lenders that are not eligible to earn interest on excess reserves (IOER) lend funds below the IOER rate to borrowers with access to the IOER facility, which in turn put these funds in their reserve accounts to earn the spread. Our findings highlight that this persistent arbitrage opportunity is not a result of the mere lack of alternative outside options of some lenders, but it crucially depends on their limited bilateral bargaining power, leading to a persistent segmentation of prices in the euro interbank market. We examine the implications of these findings for the transmission of euro-area monetary policy.

KEYWORDS: bargaining power, over-the-counter market, monetary policy, money market segmentation

JEL CLASSIFICATION: E4, E58, G21

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*This version: May 2017. We thank Klaus Adam, Morton L. Bech, Martin Diehl, Darrell Duffie, Jens Eisenschmidt, Falko Fecht, Craig Furfine, Co-Pierre Georg, Carsten Hartkopf, Matti Hellqvist, Raj Iyer, Robert King, Antoine Martin, Christoph Memmel, Alexander Müller, Joe Peek, José-Luis Peydró, Stefan Rosenthal, Jan Scheithauer, and Sascha Steffen, for valuable comments and suggestions. Puriya Abbassi and Niels Schulze are members of one of the user groups with access to TARGET2 data in accordance with Article 1(2) of Decision ECB/2010/9 of 29 July 2010 on access to and use of certain TARGET2 data. The Deutsche Bundesbank and the PSSC have checked the paper against the rules for guaranteeing the confidentiality of transaction-level data imposed by the PSSC pursuant to Article 1(4) of the issue mentioned above. The views expressed in the paper are solely those of the authors and do not necessarily represent the views of the institutions to which the authors are affiliated. Emails: puriya.abbassi@bundesbank.de, falk.braeuning@bos.frb.org, niels.schulze@bundesbank.de.

I. INTRODUCTION

In most financial systems, only selected financial institutions (banks hereafter) can hold and trade central bank reserves. The interest rate that banks charge to loan these reserves in the over-the-counter interbank market plays an important role not only for liquidity reallocation and risk-sharing in the banking sector but also for the pricing of other financial assets, and thus the functioning of the financial system as a whole. As a result, the effect of any (conventional or unconventional) monetary policy depends upon the rates at which reserve balances are traded and thus transmitted to the wider economy. Indeed, major central banks implement their monetary policy by steering an average effective level of the shortest interbank rate (i.e., the overnight interbank rate) around a defined target rate.[1]

In this paper, we ask how reliable an *average* effective overnight interbank rate is for the implementation of monetary policy. This question has re-emerged in the context of the large supply of central bank reserves in the aftermath of the Lehman failure that has pushed down the average effective overnight interbank rate well below the central bank's target rate in the United States, the United Kingdom, and the euro area.[2] In the United States, the volume-weighted median overnight interest rate—the effective federal funds rate—even decreased persistently to levels below the interest rate the Federal Reserve pays on reserves (IOER rate), which until then was commonly understood to provide a floor for the interbank interest rate (e.g., Goodfriend 2002; Friedman and Kuttner 2011). As a consequence, concerns have been raised about the efficiency of liquidity reallocation in the banking sector, and thus the efficacy of monetary policy transmission in general (e.g., Keister, Martin, and McAndrews 2008).

Bech and Klee (2011) provide a rationale for this puzzling outcome of the U.S. federal funds rate by arguing that some participants in the market for reserves, such as government-sponsored enterprises (GSEs), are not eligible to earn interest on their reserve balances, thereby limiting their outside investment options. As a result, these institutions would be willing to lend funds below the IOER rate, driving down persistently the effective federal funds rate below the IOER rate. In this paper, we show that this anomaly is not specific to the United States. Indeed, we find that even in the euro area, where the effective overnight interest rate—the Eonia rate—is above the Eurosystem's IOER rate, a substantial fraction of overnight in-

[1] While central banks typically target the average overnight rate, the variation of the overnight interest rates is commonly curtailed by a 'corridor' of policy interest rates, i.e., one that pays interest on reserve balances held at the central bank (IOER rate) and another one that is charged when banks borrow balances from the central bank (LOLR rate) directly.

[2] The role of the average effective overnight rate has also been discussed by, e.g., Keister, Martin, and McAndrews (2008) and Bindseil and Jablecki (2011). Bindseil (2004) and Whitesell (2006a, 2006b) raise similar questions while discussing the different frameworks of monetary policy implementation before the financial crisis.

terbank loans (22 percent of all euro-denominated overnight loans) trades below the IOER rate during periods of a positive (and non-zero) IOER rate. Similar to the United States, these trades are conducted by lenders that have no access to the Eurosystem's IOER facility, i.e., lenders that cannot deposit reserve balances in an interest-bearing account.

In this paper, we argue that this persistent anomaly of trades below the IOER rate reflects a deeper structural insight into the interbank market for central bank reserves. Based on a simple bilateral Nash bargaining model, we show that the price for a bilateral interbank credit is determined by both the bilateral bargaining power and the alternative investment opportunities of both the lender and the borrower of a given trade. Indeed, we argue that different access policy (e.g., being eligible or non-eligible to earn the IOER rate) is *not a sufficient condition* for the interbank market to become segmented, but that persistent *bilateral bargaining power* in the OTC interbank market *is crucial* for interest rates to diverge among market participants and settle even below the IOER rate (as argued by Furfine 2011). More generally, we show that differences in bilateral bargaining power across institutions can lead to substantial and persistent dispersion of overnight interest rates among market participants, even when outside options are similar.

To empirically test these predictions of our model, we rely on detailed transaction-level data on euro-denominated overnight interbank loans derived from the Eurosystem's payment and settlement system Target2. Our dataset contains information on the borrower and the lender of an overnight interbank loan, as well as the interest rate that they negotiate, which is necessary to test the effects of bilateral bargaining power that can be estimated only by using loan-level data.[3] We match this database with proprietary bank-level data on each bank's actual recourse to the IOER facility, i.e., the volume of excess reserve balances each bank holds at the Eurosystem's facility to earn the IOER rate. We complement these data further with day-level information, notably LOLR funding, amount outstanding associated with open market operations, and a market liquidity indicator for both the euro area money market and for the foreign exchange, bond, and equity markets. The detailed loan-level information allows us to examine the role of bilateral bargaining power and outside options on interbank loan rates at the bank-pair level, as well as to investigate the factors driving the heterogeneity in both variables.

[3] In contrast to the U.S. Fedwire data, Target2 provides information on the *ultimate* borrower and the *ultimate* lender as well as on settling sending and settling receiving institutions. This distinction is crucial for the identification of unique matches, which otherwise could bear the substantial problem of false positives as explained in Armantier and Copeland (2012) and the Research Group of the Federal Reserve Bank of New York. For our study, this dataset is crucial, as it allows us to identify the bargaining power and outside option of the actual borrower and lender of a given trade.

We use the fine granularity of our data to compute several measures of bargaining power for each trader depending on the bank's lending and borrowing concentration, respectively, in the OTC interbank lending market (e.g., the Herfindahl-Hirschman index, HHI). To measure the outside investment option of each lending institution, we make use of a distinct feature of our dataset: 29 percent of the total overnight euro interbank credit volume is provided by non-euro area lending banks. While these banks account for 22 percent of all loans in the euro interbank market and thus play an economically meaningful role in the allocation of euro-denominated central bank reserves, they do not have direct access to the Eurosystem's facilities, including open market operations, the discount window, and the IOER facility. Therefore, unlike other euro-area banks, these banks have no access to the central bank facilities and thus are limited in their alternatives to manage end-of-day excess balances, e.g., by placing unnecessary end-of-day reserves at the IOER facility to earn the IOER rate.[4] We will use this distinct difference across lending institutions to account for different outside options among lending institutions.

In line with our model's predictions, we find the following robust main results: (i) lenders with greater bargaining power over their borrowers are able to negotiate higher interest rates; (ii) lenders with outside options (i.e., access to the Eurosystem's IOER facility) charge higher interest rates (on average by about 10 basis points) for overnight loans than lenders without access to the IOER facility; (iii) the negotiated interest rates are more sensitive to the bargaining power of the lender bank if the lending institution has no outside investment option; and (iv) the bilateral interest rates can fall below the euro area's IOER rate if the bargaining power of the lender is sufficiently weak. Our results are economically meaningful. For instance, we find that during the period of a positive (and non-zero) IOER rate the interest rate differential between lenders with and without outside investment options is consistently positive and amounts to values of up to 50 basis points; on average, lenders with no access to the IOER facility (no outside option) receive about 10.3 basis points lower interest rates for overnight loans than their peers.[5] This suggests a substantial fragmentation of the euro-area interbank money market in terms of prices. Moreover, we find that about 33.4 percent of all overnight loans in our dataset settle at an interest rate below the interest rate paid on ex-

[4] As we will discuss in Section II, we use an institution-to-parent SWIFT BIC code matching table that links each institution to its ultimate parent institution at the highest consolidated level. This ensures that we can relate each institution to its ultimate parent bank to determine the existence or lack of policy access to Eurosystem's facilities, including the IOER facility. That is, we account for the fact that banks that have no direct policy access themselves might have indirect policy access through their euro-based affiliates (subsidiaries and branches).

[5] The below-IOER-rate trades disappear when the Eurosystem set the IOER rate to zero in July 2012, and, thus, removed the difference in the outside options among EA and non-EA lenders. Note, however, that these differences in outside options simply surface the deeper structural impact of the heterogeneity in bilateral bargaining power that induces the observed persistent price segmentation.

cess reserves. At the same time, we find that the borrowing counterparty of these below-IOER trades deposits more than 36 euro cents of each single euro borrowed at the Eurosystem's IOER facility to fetch the higher IOER rate, thereby making an arbitrage spread. We find this arbitrage opportunity to be persistent due to the significant bargaining power of these borrowers over lenders without outside options. This implies that the IOER rate is not necessarily a strict floor for interest rates in the euro interbank market and that it can promote arbitrage trades below the IOER rate.

To understand the variation of bargaining power as a key driver of the interbank market segmentation in more detail, we take a further step and use our model to examine its bank-pair, bank, and time dimensions. We find that bargaining power exhibits an important heterogeneity at the bank-pair level (21 percent of the variation) that cannot be explained by a common time variation and, hence, cannot be studied using aggregate interbank lending data. Our results show that banks with a high lending or borrowing concentration (i.e., lack of diversification) are less able to negotiate favorable interest rates. However, we find important heterogeneity that depends on the outside options of lenders. In particular, for lender banks without access to the IOER facility, having a well-diversified lending network strengthens their bargaining power vis-à-vis borrowing banks that have access policy.

In light of these findings, we further study the implications for monetary policy. In our setup, monetary policy affects interbank lending rates through two main channels. First, changes in the interest rate corridor for overnight depositing and lending reserves affect the value of the outside options to interbank lending, as well as the outside option differential between the banks with and without access policy. Second, monetary policy affects the bilateral bargaining power of involved participants in the interbank market. Specifically, a lower amount of liquidity provided to the banking system shifts bargaining power towards the lending banks. For instance, we find that the Eurosystem's switch from the variable rate tender to the fixed-rate, full-allotment policy in 2008 significantly strengthened the bargaining power of borrower banks. These findings have particular implications for any potential exit of the current low-interest-rate policy. The extent to which increases in the Eurosystem's policy rates will be transmitted to interbank rates depends crucially on the participation of lenders without access policy *and* the distribution of bargaining power in the interbank market. Indeed, our analysis shows that a substantial participation of banks without access to the IOER facility will put downward pressure on interbank rates when the IOER rate is moved back into positive territory (and hence different access policy across institutions matters). On the other hand, the reduction of a large amount of excess reserves (or a potential return to a variable-rate tender procedure) will shift bilateral bargaining power away from borrowers toward lender banks and increase interbank rates. More generally, the corollary of these findings is that monetary policy needs to rely on transaction-level information rather than average effective overnight interest rates in order to (i) assess frictions in interbank markets, (ii) estimate its effectiveness in affecting broader financial markets, and (iii) evaluate the potential outcomes of (conventional and unconventional) policy measures both during normal and crisis times.

Contribution to the Literature. Our findings relate to several strands of the literature. First, our study adds to the literature on monetary policy implementation and its transmission through the interbank market (Whitsell 2006a and 2006b; Berentsen and Monnet 2008; Bech and Klee 2011; and Kraenzlin and Nellen 2015). In particular, Kraenzlin and Nellen (2015) show for the Swiss market that the lack of access policy induces money market segmentation with significant repercussions for monetary policy and financial stability. In the United States, Bech and Klee (2011) argue that because government-sponsored enterprises (GSEs) are not eligible to earn interest on reserves, arbitrage opportunities arise and induce money market segmentation in the federal funds market. While both of these studies emphasize the role of access policy (or the lack thereof) for both monetary policy and financial stability, our results add another important dimension: we highlight that both the lack of access to central bank facilities *and* especially bilateral bargaining power are necessary for such arbitrage opportunities to be persistent and for money markets to become segmented (in line with Furfine 2011). As we show, our results have important implications for the conduct of monetary policy and the transmission of its stance to the wider economy.

Second, our paper contributes to the literature on trading in OTC markets. Duffie, Garleanu, and Pedersen (2005) establish bargaining power as a key determinant for OTC trades. Zhu (2012) proposes a dynamic model that introduces outside options in addition to bargaining power to study the pricing in OTC markets. While these papers study the role of bargaining power and outside options for OTC markets in general, other theoretical contributions focus on specific segments, such as the government bond market (Vayanos and Weill 2008), credit default swap markets (Atkeson, Eisfeld, and Weill 2015), and the federal funds market (Afonso and Lagos 2015a and 2015b). In this paper, we argue that in a frictionless world where borrower banks engage in Cournot-type competition, borrower bargaining positions, and thus segmentation aspects, in OTC markets fade away as every lender would provide the asset at an interest rate that equals the outside option of the borrowing banks, *irrespective* of the lender's outside options. Therefore, persistent price differentials between agents with and without outside options can only be a result of the existence of both different outside investment options *and* bilateral bargaining power of borrowing institutions. In line with this rationale, we provide empirical evidence for the role of bilateral bargaining power and outside options for the pricing of OTC-traded interbank loans.

Third, our work also adds to the literature on liquidity reallocation in interbank lending markets. Afonso, Kovner, and Schoar (2011), Acharya, Gromb, and Yorulmazer (2012), Acharya and Merrouche (2012), and Abbassi, Bräuning, Fecht, and Peydró (2013), among others, study the allocation of funds among banks in response to liquidity shocks. Our findings suggest that even when a shock affects only a subset of banks, it is transmitted to the rest of the banking sector in ways that are shaped by both the bilateral bargaining power and outside options. This is in contrast to standard models with random spot transactions where supply shocks are argued to have symmetric effects on all banks in the market. In this regard, our paper is also related to the literature that studies the OTC structure of the interbank market using network theory. In particular, several recent papers document a core-periphery structure of the interbank networks, where few banks trade with many counterparties but the majority have only a few counterparties; see, e.g., Bech and Atalay (2010), Craig and von Peter (2010), Fricke and Lux (2012), Gabrieli and Georg (2014), Iori et al. (2008), Langfield, Liu, and Ota (2014), Lelyveld and Veld (2012), and Rordam and Bech (2009). Consistent with their findings of sparse interbank networks, we find that stronger portfolio concentration affects the bank's bilateral bargaining power and thus the terms of an interbank loan.

Finally, our paper also relates to the literature that studies the role of lending relationships in the interbank market. Furfine (1999) is the first to study the role of relationship formation in interbank lending markets, especially for smaller institutions, to alleviate the problem of asymmetric information. Furfine (2001) also shows that establishing relationships can be pursued as a signalling device to show their good-credit-risk profile. Cocco, Gomes, and Martins (2009), Afonso, Kovner, and Schoar (2013), and Bräuning and Fecht (2017) show that banks rely on repeated interactions with counterparties. Our paper shows that bargaining power and outside options play an economically meaningful role beyond relationship lending, irrespective of the size of the banks. In this regard, our paper is closely related to the emerging strand of literature that studies the role of bilateral bargaining power in decentralized interbank markets (e.g., Allen and Babus 2009; Abreu and Manea 2012; Blasques, Bräuning, and van Lelyveld 2015; and Bech and Monnet 2016).

The remainder of the paper is structured as follows. Section II describes our dataset and the euro money market. Section III introduces the bargaining model, derives testable predictions, and validates them empirically. Section IV analyzes the determinants of bilateral bargaining power and discusses monetary policy implications. Section V concludes.

II. THE EURO INTERBANK MARKET AND DATA

In the euro-area interbank lending market, all euro-denominated transactions are executed with an electronic request made by a financial institution to the Eurosystem via its payment and settlement system Target2. Such a request debits the euro reserve balance account of the initiating financial institution by a stipulated amount in favor of another financial institution. All financial institutions with a banking license in the euro area have such access to Target2, which they use for settling their euro payments. Financial institutions from some European countries that are not part of the euro area, such as Switzerland and the UK, are also granted Target2 access to facilitate euro transactions among European banks.[6] Other banks, however, will need an account with a European bank (or any of their branches or subsidiaries headquartered in the European Union) in order for them to send (or receive) euro-denominated payments. In these cases, the house bank will act as an intermediary institution settling the transaction for them.

Banks have no incentives to hold reserve balances in large amounts at the close of business day in excess of mandatory requirements because these excess reserves do not earn interest given the current framework of the Eurosystem. However, euro-area banks (EA banks, henceforth) can and generally do transfer end-of-day balances in excess of mandatory requirements to their IOER facility accounts held with the Eurosystem, where these excess reserves are remunerated with the prevailing IOER rate. Other banks, on the other hand, including banks from European countries that are not part of the euro area (non-EA banks, henceforth), do not have such an access policy to the Eurosystem's IOER facility; unused excess reserve balances will then remain in their Target2 accounts and bear no interest rate.[7] That is, these banks have the incentives to exchange their end-of-day balances for interest-bearing overnight assets as long as the interest rate is greater that the shadow cost of leaving the reserves at their accounts, which is 0 percent. We will use this distinct feature of the Eurosystem's access policy between EA and non-EA banks to identify differences in outside options.

[6] More precisely, banks from countries that are part of the European Economic Area (i.e., European Union countries as well as Switzerland, Norway, Lichtenstein, and Iceland) are eligible to access Target2 directly.

[7] With the introduction of negative interest rates paid on excess reserves in mid-2014, this institutional design was changed. After June 11, 2014, any bank that had positive balances in its Target account is charged with the prevailing IOER rate.

Our empirical analysis is based on transaction-level data on overnight interbank money market loans from Target2 for the period from June 2008 through June 2012.[8] These data allow us to identify the ultimate borrower and the ultimate lender bank[9], the amount lent, and the interest rate.[10] Having access to loan-level data is crucial to study the effects of bargaining power and outside options that depend on the specific borrower and lender of a given loan. We supplement these transaction-level data on overnight interbank loans with proprietary bank-level data on individual banks' daily recourses to the Eurosystem's IOER facility, i.e., the account at which excess reserves are remunerated and can be deposited overnight. That is, for each EA bank, we observe the amount of the end-of-day balances a given bank transfers to its account held with the Eurosystem to earn the IOER rate. In addition, we obtain daily data on the total amount outstanding associated with the Eurosystem's open market operations, the total amount of excess reserves held by all banks at the IOER facility, the IOER rate, a money market liquidity indicator, and a liquidity measure for the foreign exchange, bond, and equity market in the euro area, all of which are provided by the Eurosystem's Statistical Data Warehouse.

Our raw dataset comprises a total of 1559 borrowers and 2116 lenders. We account for the different bank branches by consolidating banks on the first eight digits of their respective SWIFT BIC code (from the initial eleven digits). Moreover, we use a parent-institution SWIFT BIC code matching table that links each (subsidiary) institution to its ultimate parent institution at the highest consolidation level. This procedure ensures that we can relate each institution to its ultimate parent institution to determine the existence or lack of access to the Eurosystem's facilities, including the IOER facility, which will be our measure for a bank's outside option. Moreover, we prune our dataset as follows. We restrict ourselves to transactions carried out across consolidated banking groups as opposed to intra-banking-group trans-

[8] The start of our sample corresponds to the official launch of Target2, while we have chosen the ending date so as to ensure that our results are driven by the Governing council's decision to set the IOER rate to zero as of July 11, 2012. Moreover, with the IOER facility rate being set to zero, the opportunity cost of having end-of-day excess balances not transferred to the IOER facility to earn the interest on excess reserves reduces to zero too and thus diminishes the lenders' outside option. In Appendix Figure 1, we show that as soon as the outside option of EA banks reduces to zero in response to the interest rate cut in the mid of 2012 and thus equals the outside option of non-EA lending banks, we do not observe any trades below the IOER rate. Note, however, that these differences in outside options simply surface the deeper structural impact of the heterogeneity in bilateral bargaining power that induces the persistent price segmentation as we will discuss in Section III.1.

[9] In contrast to the U.S. Fedwire data, Target2 provides information on the ultimate borrower and lender as well as on settling sender and settling receiver bank. The distinction is crucial for the identification of unique matches, which otherwise could bear the substantial problem of false positives as explained in Armantier and Copeland (2012).

[10] The identification of each overnight interbank loan is based on a refined version of the Furfine (1999) algorithm as developed by Arciero et al. (2016). The algorithm-based estimation quality is checked against actual euro area overnight loans from supervisory datasets (Bank of Spain) and from private datasets (Italy's e-MID). Arciero et al. (2016) and De Frutos et al. (2014) validate the Target2 interbank loan data using the Italian uncollateralized e-MID trading platform and the Spanish unsecured post-trading platform MID, respectively. The quality checks reveal that the Target2 interbank loan-level data matches well with the actual Italian and Spanish unsecured money market data (identifying incorrectly less than 1% of payment legs as interbank loans), which also verifies the unsecured nature of the loans in our data. The quality of the interbank data for the United States and the United Kingdom is not easy to validate due to the lack of actual transaction-level data (Armantier and Copeland 2012).

actions.[11] The reason being, that the effective lending rate in the euro-area interbank market is governed primarily by transactions between banks of different banking groups.[12] We also restrict ourselves to banks that trade with more than one counterparty on any given day, thereby reducing our sample to the most active banks in the market. (All results are, however, robust against the exclusion of these banks.) We also exclude non-EA borrowers from the analysis and restrict ourselves only to EA borrowing banks, as those borrowing banks are counterparties to the Eurosystem and therefore crucial for the monetary transmission process in the euro area.

Our final sample consists of 376 EA borrowers and 919 (EA and non-EA) lenders accounting for 89 percent of the loans of the total overnight interbank market. Out of these 919 lenders, 549 banks are from countries with the euro as the official currency (EA lenders). The remaining 370 lenders stem from countries outside of the euro area (non-EA lenders).[13] Overall, more than 29 percent of the total overnight interbank credit volume (22.6 percent of all loans) is provided by non-euro area lending banks thereby rendering their role in the euro-area interbank lending market economically meaningful.

III. PREDICTIONS FROM A NASH BARGAINING MODEL

In this section, we introduce a simple model that guides us in examining the role of bargaining power and different outside options between the involved parties for the pricing of interbank loans in a decentralized over-the-counter market. We then use our loan-level data to evaluate the model predictions.

III.1 THE MODEL

Our model's main intuition is that the price for a bilateral interbank credit is determined by the bargaining power and alternative investment opportunities of both the lender and the borrower of a given trade. In particular, if, for a given trade, the lending bank has more bargaining power over the borrower (or, equivalently, the borrowing bank has less bargaining power over the lender of that trade), the lending bank can fetch a higher interest rate

[11] That is, any loan between, say, Deutsche Bank (Germany) and Santander (Spain) will be reflected in our dataset while a loan between, say, Deutsche Bank (Germany) and Deutsche Bank (Spain) will not be included.

[12] This is an outcome of the Eurosystem's operational framework that grants access to its open market operations to all banks that can provide eligible collateral. In the United States, the allocation of central bank reserves in monetary policy operations relies on a small set of pre-determined primary dealers.

[13] From these 370 non-EA lenders, 186 banks are from European countries (such as United Kingdom, Switzerland, Norway, etc.), 138 banks from Asian countries (including Western Asia) and Russia, 32 banks from African countries (including Egypt), and 14 banks headquartered in North and South America. Lenders from European countries that do not have the euro as their currency are the largest group of non-EA lending banks accounting for about 63% of the total non-EA lending volume (58% of loans). Banks from Asian countries are the second largest group with about 37% of total non-EA lending volume (31% of loans).

on the loan. Moreover, if the lending bank has better outside investment options, everything else equal, the lender will negotiate a higher rate to reduce the otherwise higher opportunity costs. In consequence of bilateral bargaining power and the existence or lack of alternative investment options for some banks, the money market can become segmented with respect to the pricing of OTC-traded interbank loans, i.e., with some bank pairs trading at substantially different prices than others.

Denote the set of euro area banks by N^{EA}, the set of non-euro area banks by N^{non-EA}, and let $N = N^{EA} \cup N^{non-EA}$ represents the set of all banks. All banks within the euro area (EA banks, hereafter) have full recourse to the Eurosystem's facilities, in particular, the standing facilities. That is, EA banks can borrow euro-denominated overnight funds from the marginal lending facility of the ECB at a penalty rate $\bar{r}_t$, and park excess reserves at the IOER facility to earn the remuneration rate $\underline{r}_t$ (the IOER rate). The interest rates of the marginal lending facility and the IOER facility are set so as to define the ceiling and the floor for interest rates of overnight interbank loans, hence building a corridor with the width $corridor_t = \bar{r}_t - \underline{r}_t$. However, non-euro area banks (non-EA banks, hereafter) do not have access to the Eurosystem's standing facilities and may trade at interest rates outside the corridor.

Assume that each trading session is as long as a day and that for each trading day, each lender bank $i \in N$ is randomly matched with only one borrower bank $j \in N$ and that each loan is of the same euro-denominated value (scaled to one).[14] At the end of the trading day, each EA (borrower and lender) bank has the outside option to draw on the central bank's standing facilities to cover its liquidity needs or invest excess funds. On the other hand, non-EA banks have no access to Eurosystem's standing facilities as discussed above.

The bargaining problem that these two borrower and lender banks face can be represented in a generalized Nash-type solution setup (Binmore 1992; Bech and Klee 2011). The bargaining problem between a lender bank i and a borrower bank j at time t can be defined as a tuple $(R, d) \in S$ where R denotes the set of feasible bargaining outcomes and $d = (d^l, d^b)$ is the threat point that determines the value of the outside options for the lender and borrower bank if the two parties fail to reach an agreement. For any given interbank loan, this means that the lending bank and borrowing bank bargain about the interest rate $r \in R$ that the borrower will need to pay to the lender for obtaining funding. In this context, the unique solution to the bargaining problem is determined by the function $f: S \to R$. With profit-

[14] We only focus on the pricing and abstract from the detailed structure of the matching process and the forces behind interbank market participation that determine whether a bank supplies or demands funds. Similarly, we abstract from decisions about the loan volumes.

maximizing risk-neutral agents, the utility of agents resulting from a trade simply equals the interest income, such that the generalized Nash solution can be written as:

$$r_{i,j,t} = \underset{d_{i,t}^{l} \leq r \leq d_{j,t}^{b}}{\arg\max} (r - d_{i,t}^{l})^{\theta_{i,j,t}} (-r + d_{j,t}^{b})^{1-\theta_{i,j,t}}$$

where $\theta_{i,j,t} \in (0,1)$ denotes the bargaining power of the lending bank (over the borrower bank) and $1 - \theta_{i,j,t}$ is the bargaining power of the borrowing bank (over the lending bank). Hence, whenever the lender's bargaining power increases, the borrower's bargaining power decreases, and vice versa. Therefore, changes in $\theta_{i,j,t}$ are always associated with a shift in the bilateral bargaining power from one bank to the other. Also note that $\theta_{i,j,t} = 1$ corresponds to the situation where the lender has full bargaining power over the borrower.

The solution to the convex optimization problem is characterized by the first-order condition that we rearrange to obtain

$$r_{i,j,t} = \left(1 - \theta_{i,j,t}\right) d_{i,t}^{l} + \theta d_{j,t}^{b} = d_{i,t}^{l} + \theta_{i,j,t}(d_{j,t}^{b} - d_{i,t}^{l}). \quad (1)$$

The outside option of any EA bank (to draw on the central bank facilities at the end of the day) is given by the all-in-cost of the standing facilities of the Eurosystem, i.e. $\left(d_{i,t}^{l}, d_{j,t}^{b}\right) = (\underline{r_t}\ , \bar{r}_t)$. Therefore, the interest rate between EA banks (from EA lender to EA borrower) can be written as

$$r_{i,j,t} = \left(1 - \theta_{i,j,t}\right) \underline{r_t} + \theta_{i,j,t} \bar{r}_t = \underline{r_t} + \theta_{i,j,t}\, corridor_t \ \forall\ i,j \in N^{EA}.$$

That is, the bilaterally agreed interest rate of the loan between two EA banks equals the Eurosystem's IOER facility rate plus a spread that depends on the width of the interest rate corridor and the bank-pair bargaining power of the lender bank $\theta_{i,j,t}$. If two EA banks agree on the pricing of the loan, the interest rate should hence not be lower than the rate paid on excess reserves.

Non-EA lending banks have no outside investment options for reserves held in excess as they cannot draw on the Eurosystem's IOER facility. The threat point between non-EA lenders and EA borrowers is thus given by $\left(d_{i,t}^{l}, d_{j,t}^{b}\right) = (0\ , \bar{r}_t)$.[15] Substituting the outside options into Equation (1) leads to the following interest rate between non-EA lenders and EA borrowers

$$r_{i,j,t} = \theta_{i,j,t}\, \bar{r}_t = \theta_{i,j,t} \underline{r_t} + \theta_{i,j,t} corridor_t \ \forall\ i \in N^{non-EA}, j \in N^{EA},$$

[15] Setting the outside options for non-EA lender banks to zero can be seen as a conservative approach. In principle, a non-EA bank may also convert euros in the currency of its home country and earn the IOER rate paid by its central bank (if the foreign central bank has an IOER policy).

which is a function of the euro area's interest rate corridor width, the Eurosystem's interest rate paid on excess reserves, and the bilateral bargaining power.

From these bilaterally agreed equilibrium interest rates, we can derive several comparative statics that will guide our empirical analysis:

Prediction 1: $\frac{\partial r_{i,j,t}}{\partial corridor_t} > 0, \forall i, j \in N$. *The interest rates charged by both EA and non-EA lending banks increase as the width of the interest rate corridor of the Eurosystem increases.*

Prediction 2: $\frac{\partial r_{i,j,t}}{\partial \underline{r_t}} > 0, \forall i, j \in N$. *The interest rates charged by both the EA and non-EA lending banks increase with the level of the interest rate paid on excess reserves.*

Prediction 3: $\underline{r_t} > 0 \Rightarrow r_{i,j,t} < r_{i',j,t}\ \forall i \in N^{non-EA}$ *and* $i', j \in N^{EA}$. *The interbank money market for overnight loans becomes segmented in terms of prices if the euro area's IOER facility rate is positive.*

Prediction 4: $\frac{\partial r_{i,j,t}}{\partial \theta_{i,j,t}} > 0, \forall i, j \in N$. *Lenders with greater bargaining power relative to their borrowers are able to bargain higher interest rates.*

Prediction 5: $\underline{r_t} > 0 \Rightarrow \frac{\partial r_{i,j,t}}{\partial \theta_{i,j,t}} > \frac{\partial r_{i',j,t}}{\partial \theta_{i,j,t}}\ \forall i \in N^{non-EA}$ *and* $i', j \in N^{EA}$. *The interest rates are more sensitive to the bargaining power of non-EA lender banks if the euro area's IOER facility rate is above the non-EA bank's outside option (which is zero).*

Prediction 6: $\frac{\underline{r_t}}{corridor_t} > \frac{\theta_{i,j,t}}{1-\theta_{i,j,t}} \Rightarrow r_{i,j,t} < \underline{r_t}, \forall i \in N^{non-EA}, j \in N^{EA}$. *The rates charged from non-EA lenders can fall below the euro area's IOER facility rate if the bargaining power of the lender is sufficiently small. Hence, the interest rate paid on excess reserves does not provide a floor on euro overnight loans granted from borrowers from non-EA countries.*

It is important to highlight that the determination of the interest rate for the loan between any two banks relies on the following features: (i) the lending and borrowing bank have (direct or indirect) access to Target2 and can transfer euros to one another; (ii) the borrowing (EA) bank has access to the Eurosystem's IOER facilities to cover unmet liquidity needs or earn the IOER rate; and (iii) non-EA lenders have the outside investment option for depositing end-of-day euros at an annualized rate of return of 0 percent.

A necessary condition for the differences in the interest rates that EA and non-EA lenders charge (Prediction 3) is the existence of bargaining power in the interbank market. In a frictionless world where borrower banks engage in Cournot-type competition ($\theta_{i,j,t} \rightarrow 1$), borrower bargaining positions and thus segmentation aspects fade away as every lender would provide loans at an interest rate that equals the outside option of the borrowing banks, irrespectively of the lender's outside options. Therefore, persistent interest rate differentials between EA lenders and non-EA lenders can only be a result of the existence difference in bargaining power. We next test the model's predictions using our loan-level data.

III.2 EMPIRICAL EVALUATION

We start our empirical analysis by looking at summary statistics. Table 1 shows that EA lender banks negotiate on average higher rates than non-EA lending banks. Moreover, interest rates for EA lending banks settle on average more than 31.7 basis points above the prevailing IOER rate, while we find that overnight loans by non-EA lending banks to settle around 16.4 basis points above the IOER rate. In Figure 1, we show the evolution of the spread between the interest rates of EA-lenders and non-EA lenders graphically. The spread between these interest rates is consistently positive and amounts to values of up to 50 basis points. This interest rate differential is economically sizable and has important consequences for banks' refinancing conditions as 22.6 percent of all loans are provided by non-EA lending banks, where the loan amounts are comparable across both groups. Thus based on this initial finding, prices appear to be segmented in the euro-area interbank lending market. Based on our model predictions and the unique loan-level data, we next examine the role that differences in bargaining power and outside options play in this segmentation of prices.

To that aim, we examine the pricing of interbank overnight loans in a linear regression framework using the following specification:

$$(\text{Rate}_{i,j,t} - \text{IOER}_t) = \alpha + \beta' x_{i,j,t} + \text{fixed effects} + u_{i,j,t}, \qquad (2)$$

where *Rate* is the interest rate of the loan (in percent) between lender *i* and borrower *j* at day *t*, $u_{i,j,t}$ is an error term, and *x* is a vector that includes the following set of independent variables dictated by our model: (i) the width of the interest rate corridor, $Corridor_t$, and (ii) the level of the interest rate paid on excess reserves (IOER rate), r_t. Moreover, we define a dummy variable $nonEA\text{-}EA_{i,j}$ that equals the value of one if the loan is between a non-EA lender and an EA borrower, and zero if it is a loan between an EA lender and an EA borrower. As a proxy for the lender's and the borrower's bargaining power ($\theta_{i,j,t}$), we use the lending and the borrowing concentration, respectively, measured by the Herfindahl-Hirschman index, HHI (e.g., Afonso, Kovner, and Schoar, 2013). The HHI equals the sum of the squared bank-pair lending and borrowing shares, respectively. Hence, an HHI close to one indicates a highly concentrated interbank portfolio, and an HHI close to zero a highly diversified interbank portfolio. In accordance with our model explained above, we associate a bank's HHI with its bargaining power as follows: a high HHI of the lender bank suggests a highly concentrated portfolio and thus a low $\theta_{i,j,t}$, i.e., low bargaining power of the lender and high bargaining power of the borrower; a high HHI for a borrower bank corresponds to a lower $1 - \theta_{i,j,t}$, i.e., lower bargaining power of the borrower, which corresponds to higher bargaining power of the lender. We compute the HHI variables based on a rolling window of the last 30 days, but the results are very robust to using longer or shorter windows. Finally, we interact our proxy of bargaining power with the $nonEA\text{-}EA_{i,j}$ dummy.

In our tightest specification, we further control for a common time variation in interest rates by including day fixed effects. Moreover, we include borrower-lender pair fixed effects to control for time-invariant bank-pair specific heterogeneity such as prior trading relationships (Ashcraft and Duffie 2007; Cocco et al. 2009; Afonso, Kovner, and Schoar 2013; Bräuning and Fecht 2017) and geographical distance (Degryse and Ongena 2005). Note that bank-pair fixed effects absorb bank fixed effects, both for the borrower and for the lender, respectively. More specific to interbank networks though, market power might come from an institution's centrality in the interbank network (Craig and von Peter 2010) or the time needed to find a counterparty (Afonso and Lagos 2015). These drivers, however, are relatively constant over time and thus will be captured by bank-specific fixed effects. We estimate Equation 2 by ordinary least squares.[16]

Consistent with our first model prediction, we find in column 1 of Table 2 that the interest rate on an overnight loan increases with the width of the interest rate corridor. In column 2, we include the IOER rate to test our second model prediction, i.e., whether the interest rates charged by both the EA and non-EA lending banks increases with the level of the interest rate paid on excess reserves. The positive and significant point estimate indicates that if the central bank raises the outside options (i.e., reduces the shadow cost) also the interbank spreads will increase. Our estimates indicate that an increase in the corridor width by 50 basis points is associated with an increase in the loan spread by 22.78 basis points, while an in-

[16] We provide robust standard errors in all tables. Our main results are robust against single-clustered standard errors at bank-pair level and double-clustering at the bank-pair and day level.

crease in the IOER rate by 25 points is associated with an increase in the loan spread by about 3.58 basis points.

We next estimate the effect of differences in outside option on interbank rates. In line with model prediction 3, we find in column 3 of Table 2 that the interest rate is lower if the lender bank is a non-EA bank that does not have access to the IOER facility as compared with loan rates between EA lender and EA borrower. In economic terms, the difference in the interest rate differentials amounts to roughly 15.16 basis points on average. In column 4, we test whether greater bargaining power is associated with more favorable loan terms by including the borrower's and lender's HHI as a proxy for their individual bargaining power. Consistent with prediction 4, we find that both lenders and borrowers with greater bargaining power over their respective counterpart are able to exert more favorable terms, i.e. higher rates for the lender and lower prices for borrowers, respectively.[17] These results are robust to the inclusion of time fixed effects (see column 5). In this specification, we estimate that the interest rate differential between non-EA and EA lender banks amounts to a level of up to 10.30 basis points.

Our model analysis suggests that the lender's bargaining power is more relevant for the interest rate determination if the lender does not have access to outside options (prediction 5). In column 6, we therefore examine whether our proxy for bargaining power has a stronger effect on rates for non-EA lenders. Indeed, we find that the coefficients of the interaction terms *Lender's HHI*Dummy(nonEA-EA)* and *Borrower's HHI*Dummy(nonEA-EA)* and are statistically significant and carry a negative sign. This suggests that non-EA lender banks with a higher lending concentration (i.e., that have particularly little bargaining power over their EA borrowers) will obtain significantly lower rates than a bank with a similar lending concentration but *with* access to the IOER facility. Similarly, borrowing EA banks with a high bargaining power can obtain significantly lower interest rates from their non-EA lenders than what they have to pay to EA lending banks, suggesting that bargaining power contributes to a segmentation of prices in the euro-area money market. This key result is robust to the inclusion of bank-pair fixed effects in addition to time fixed effects (column 7), which absorb any time-invariant borrower, lender, and bank-pair heterogeneity. Therefore, in the specification with bank-pair fixed effect, the level effects of the portfolio concentration variables (HHIs) are identified from changes over time within a given bank pair only and not from the cross-section. Indeed, we find in this specification that, unlike non-EA lenders, EA lenders with a

[17] Recall from Section III.2 that a high HHI of the lender bank suggests a highly concentrated portfolio and thus a low θ, i.e., low bargaining power of the lender, while a high HHI for a borrower bank indicates lower bargaining power of the borrower, i.e., higher bargaining power of the lender.

higher HHI obtain higher interest rates, potentially because these lenders to some degree shop around for trades that offer higher returns.

Our model's notion is that if the non-EA lender has limited (or no) bargaining power relative to the borrower, the interest rate for an overnight loan is low and can even fall below the IOER rate of the Eurosystem (prediction 6). Figure 2 provides evidence for the existence of such interbank money market trades that settle below the IOER rate in the euro area. From Table 1, we can see that every third transaction (33.4 percent) between non-EA lenders and EA borrower is conducted at an interest rate below the IOER rate; more than 5 percent of these non-EA lending trades are conducted at more than 10 basis points below the IOER rate.[18] Moreover, from Figure 2 we see that towards the end of our sample, more than 90 percent of non-EA-to-EA loans were conducted at interest rates below the IOER rate, while the below-IOER-rate trades disappear when the IOER rate was set to zero, and, hence, there was no difference in the outside options of EA and non-EA lenders (Appendix Figure A1). Note, however, that these differences in outside options simply surface the deeper structural impact of the heterogeneity in bilateral bargaining power that induces the persistent price segmentation as discussed in Section III.1.

To examine the relationship between the below-IOER-rate trades and bargaining power more closely, we estimate the following linear probability model:

$$\text{Below IOER Rate}_{i,j,t} = \alpha + \beta' x_{i,j,t} + \text{fixed effects} + u_{i,j,t}, \qquad (3)$$

where *Below IOER Rate* is a binary variable that equals the value of one for any loan between lender *i* and borrower *j* at day *t*, where the negotiated interest rate is below the IOER rate prevailing on that day, and zero otherwise. The vector *x* includes the same explanatory variables as in Equation (2).

In columns 1 and 2 of Table 3, we find that a larger corridor, as well as a larger IOER rate, decreases the probability of a loan occurring at a rate below the IOER rate. In column 3, we find that loans between non-EA lenders and EA borrowers have a statistically significantly larger probability of occurring below the IOER rate. The estimated coefficient indicates an economically sizable increase by 31.4 percentage points if the lender does not have access to the IOER facility. Similarly, in columns 4 and 5 we find that bargaining power drives the probability of below-IOER-rate trades. In economic terms, a lender with the highest lending concentration is about 6.7 percentages points more likely to grant an interest rate below the

[18] Less than 2% of transactions that are traded below the IOER rate are between EA lending and EA borrowing banks. We have excluded those trades from our analysis. However, the results are quantitatively similar when we include them.

IOER rate (see column 5). Column 6 shows that this effect results from the non-EA lenders. When EA borrowers have bargaining power over non-EA lenders, there is a higher probability that they can borrow funds at rates below the IOER rate. Column 7 shows that this key result is robust to the inclusion of bank-pair fixed effects. (The change in the level effect for the lender's HHI resembles the finding of Table 2, column 7.)

Our findings suggest that the different outside options for non-EA lending banks (as compared to EA banks) in combination with the existence of bilateral bargaining power create an arbitrage opportunity for EA borrowers. The basic mechanism of this arbitrage trade is that non-EA lenders lend euro funds to EA borrower at lower rates due to their limited outside options and a lack of sufficient bargaining power. For these non-EA lenders, any non-zero, positive interest rate exceeds the 0 percent they would otherwise earn by leaving the excess end-of-day funds on their balance accounts. This then means that the interest rate for a loan between a non-EA lender and an EA borrower can indeed fall below the IOER rate. The level by how much it settles below the prevailing IOER rate depends on the lender's bargaining power over the borrower (or, equivalently, the borrower's bargaining power over the lender).

The EA bank that borrows funds from a non-EA lender at a rate below the IOER facility rate could deposit these additional funds at the IOER facility and earn the corresponding IOER rate from the Eurosystem, thereby making a risk-free spread. We test this arbitrage mechanism, by examining each bank's individual daily recourse to the IOER facility and study how the amount of these deposits depends on interbank conditions, in particular on the amount the bank borrowed in the interbank market at an interest rate below the IOER rate. We use the following linear model:

$$\text{Excess Reserves Held at IOER Facility}_{j,t} = \alpha + \beta' x_{j,t} + \text{fixed effects} + u_{j,t}\,, \qquad (4)$$

where *Excess Reserves Held at IOER Facility* is the (logarithm of) the amount of reserves held in excess at the IOER facility by bank j at day t to earn the Eurosystem's IOER rate. The vector of independent variables $x_{j,t}$ includes both the (log) amount of interbank credit borrowed below and above the IOER rate by bank j on day t prior to going to the IOER facility at the end of day t. We also include the average price paid by each bank on below-IOER-rate loans and above-IOER rate loans as controls and include bank and day fixed effects.

Table 4 presents the estimation results. In columns 1 to 3, we find a positive and significant relationship between trades below the IOER rate and the reserves transferred to the IOER facility by the end of the business day. Economically, we find that for every given euro borrowed on that given day below the IOER rate, 25.2 euro cents are held at the IOER facility at the end of the business day to earn the overnight IOER rate paid by the Eurosystem (column 3). We also find that banks that borrow more funds in the interbank market at a rate above the prevailing IOER rate hold significantly less excess reserves in their deposit facility accounts. Also, the economic effects are quantitatively smaller than for the amount of funds borrowed below the IOER rate.

A potential concern with our specification could be that the amount borrowed below the IOER facility rate is endogenous, thereby potentially biasing our coefficient estimate. In column 4, we therefore use an IV regression and instrument, for each bank, the amount borrowed below the IOER rate with the number of its non-EA lenders that do not have access to the Eurosystem in the period from July 1, 2008 through December 31, 2008. This instrument is exogenous to the reserves actually transferred to the IOER facility (our left-hand side variable). Moreover, due to the high persistence in interbank lending relationships, for each bank, a larger number of non-EA lender counterparties in the reference period is associated with a larger number of non-EA lenders on any subsequent day in the sample, and thereby is associated with a larger amount of funds borrowed from these non-EA banks at a rate below the IOER rate. Using this IV regression, we find qualitatively similar but quantitatively slightly larger effects: out of every single euro borrowed below the prevailing IOER rate, we estimate that banks deposit 36.5 euro cents at the IOER facility at the end of the business day. These results provide a new insight into the motives and distribution of reserve holdings across different institutions: some banks hold large amounts of excess reserves due to persistent arbitrage as described in this paper.

IV. BARGAINING POWER AND MONETARY POLICY IMPLICATIONS

The previous results show that bilateral bargaining power plays a key role in the pricing of OTC-traded interbank loans in the euro-area money market. Understanding bargaining power is therefore important to understand what determinants promote or hamper the proper functioning of the interbank market and the transmission of monetary policy. In this section, we more closely examine the determinants of bargaining power and evaluate the implications of monetary policy changes on interbank lending rates.

IV.1 UNDERSTANDING THE VARIATION IN BARGAINING POWER

To examine the bank-pair, bank, and time dimension of bargaining power in more detail, we first rearranging Equation (1) to back out the bargaining parameter $\theta_{i,j,t} = \frac{r_{i,j,t} - d^{l}_{i,t}}{d^{b}_{j,t} - d^{l}_{i,t}}$. Recall that $\theta_{i,j,t}$ measures the bilateral bargaining power that the lender *i* exercises over borrower *j* at day *t*. As before, $\theta_{i,j,t}$ € (0, 1) denotes the bargaining power of the lending bank and 1– $\theta_{i,j,t}$ is the bargaining power of the borrowing bank.

If we decompose the resulting bargaining power $\theta_{i,j,t}$ in several dimensions, we find that about 60.8 percent of the overall variation in $\theta_{i,j,t}$ can be attributed to day fixed effects and 30.9 percent to bank-pair fixed effects. Moreover, 20.6 percent can be attributed to bank-pair fixed effects after controlling for day fixed effects. This suggests that our bargaining power measure has important heterogeneity at the time dimension but also at the bank-pair level, which cannot be explained by common time variables. This dimension can only be analyzed by disaggregated loan-level interbank lending data, which is what we do in the next step.[19]

To study the determinant of bargaining power more closely, we model the bilateral bargaining power using the following generalized linear estimation equation:

$$E(\theta_{i,j,t}) = \frac{\exp(\beta' x_{i,j,t})}{1 + \exp(\beta' x_{i,j,t})}, \qquad (5)$$

where β is a parameter vector, and x includes the lending and borrowing concentration index HHI (e.g., Afonso, Kovner, and Schoar 2013).[20] Additionally, we also include respective quadratic terms of these variables to account for potential nonlinearities, motivated by the significant heterogeneity and asymmetry of the HHIs (see Table 1). To estimate the effects of monetary policy operations on bargaining power, we use the (logarithm of the) total amount outstanding associated with the Eurosystem's open market operations (i.e., main refinancing operations and longer-term refinancing operations) and a binary variable that takes the value one on any day after October 15, 2008, i.e., when the Eurosystem introduced the fixed-rate, full allotment (FRFA) policy. Given the documented interbank market segmentation, we es-

[19] This is very much in line with what Furfine (2011) argues for the U.S. federal funds market.

[20] In our robustness specifications, we have used two different variables often used in the related literature: (i) the borrower's borrower preference index (BPI) and the lender's lender preference index, LPI (e.g., Cocco, Gomez, and Martins 2009). The BPI and the LPI measure for each bank-pair the relative amount that they have been borrowing and lending to a given counterparty relative to the overall borrowing and lending volume, respectively, thereby accounting for existing trading partnerships and portfolio concentration (Afonso, Kovner and Schoar, 2013). (ii) we compute the (in-degree and out-degree) network centrality for both the borrower and the lender as the number of lenders the borrower maintains a trading relationship with and the number of borrowers the lender maintains trading relationships with (e.g., Craig and von Peter 2014). The results are qualitatively similar.

timate equation (5) for non-EA-lender-EA-borrower pairs and EA-lender-EA-borrower pairs separately to account for potentially heterogeneous effects.

In column 1 of Table 5, we find that lenders (both EA and non-EA banks) with a higher HHI have less bargaining power over their respective borrowers, confirming that the HHI is a good proxy for bargaining power. The effect is quantitatively larger for non-EA banks (see column 3), indicating that specifically for these lenders diversification in the interbank market helps to bargain higher prices. Marginal effects at the means are presented in columns 1' – 4'.[21] In columns 2 and 4, we find an important non-linearity in portfolio diversification: a strong borrowing concentration leads to more bargaining power for the non-EA lender, and vice versa. For EA lending banks, this effect is quantitatively smaller. This finding suggests that non-EA lenders, in contrast to EA lending banks, are much less able to use the lack of diversification of the EA borrower to bargain higher interest rates in their favor. In Figure 4, we illustrate the effect of changes in lending and borrowing concentration on the bargaining power graphically.

Common to all specification in columns 1 to 4 is that we find that the Eurosystem's monetary policy affects bargaining power in the interbank market. Our results show that the bargaining power of the lending bank (i.e., $\theta_{i,j,t}$) decreases when the Eurosystem increases its liquidity provision through open market operations. We also find that the introduction of the fixed-rate full allotment policy decreases primarily the bargaining power of the non-EA lending banks over their borrower. We do not find a similarly strong effect for EA lenders. Moreover, we find that an increase in the aggregate level of excess reserves decreases the bargaining power of both EA and non-EA lending banks. Further, we find that a borrower that holds a larger share of the aggregate reserves has a greater bargaining power over its lender banks. The effects are qualitatively similar to loans from both non-EA and EA lenders, respectively. Finally, our results show that higher money market liquidity reduces the bargaining power of lender banks in the overnight lending market. Similarly, higher market liquidity associated with foreign exchange, bond, and equity markets reduces the bargaining power of lenders.

Given the importance of outside options and bargaining power for determination of interbank lending rates, we next elaborate on various euro-area monetary policy scenarios and derive possible outcomes for the overnight price of interbank funding in the euro area.

[21] Marginal effects are valid for variables that enter linearly. For variables that also enter in quadratic terms, we plot the changes in bargaining power instead, see Figure 4.

IV.2 IMPLICATION FOR MONETARY POLICY

As a starting point, we compute the quantity-weighted average of the interest rate charged by a typical EA lender and the interest rate charged by a typical non-EA lender. The notion of this approach being that, looking at an average interest rate that does not account for the segmentation (as documented above) in money markets can be misleading. Let λ^f denote the fraction of loans granted by non-euro area lenders, then the average interest rate r_t is given by:

$$r_t = \lambda_t^{EA} r_{EA,EA,t} + (1-\lambda_t^{EA}) r_{non\text{-}EA,EA,t}\,, \qquad (6)$$

where $r_{EA,EA,t}$ is the typical interest rate charged from EA lenders, and $r_{non\text{-}EA,EA,t}$ is the typical interest rate charged from non-EA lenders. Following our Nash bargaining model from Section III, the bank-pair interest rate is $r_{i,j,t} = r(\underline{r}_t, \bar{r}_t, x_{i,j,t})$, with r(.) given in equation (1). For loans between EA lenders and EA borrowers, we compute the interest rate evaluated at the mean value of the variables as $r_{EA,EA,t} = r(\underline{r}_t, \bar{r}_t, \tilde{x}_{i,j,t})$ where $\tilde{x}_{i,j,t}$ is the mean of the co-variates for the pairs of EA lenders and EA borrowers, while we compute the interest rate be-tween non-EA lenders and EA borrowers as $r_{non-EA,EA,t} = r(0, \bar{r}_t, \hat{x}_{i,j,t})$ with $\hat{x}_{i,j,t}$ being the mean of the covariates for the pairs of non-EA lenders and EA borrowers.

In Figure 5, we present the possible outcomes for the (effective) overnight interest rate in response to changes in the IOER rate and the excess reserves provided to the banking sec-tor. For our analysis, we use values for the monetary policy instruments that we actually ob-serve during our sample period. We set the corridor width at 1.5 percent for the analysis of the pricing of overnight loans (as changes to the corridor width will have only a level effect). We analyze the role of loans provided by non-EA lenders while considering the following scenar-ios: (i) low market participation (12.9 percent of all loans granted by non-EA lenders) and (ii) high market participation (33.7 percent of all loans granted by non-EA lenders) based on the empirical distribution borne out by the data.[22]

The overall finding can be summarized as follows: (i) the effective interest rate is posi-tively related to a decrease in the supply of excess reserves. But, the effect of a change in ex-cess reserves is nonlinear and stronger for lower levels of excess reserves; (ii) an increase (or decrease) in the interest rate paid on excess reserves increases (decreases) the effective over-night interest rate; (iii) if monetary policy changes these two measures at the same time, the

[22] We have also analyzed the effects of policy changes using a simple model of non-EA lender participation. The results (not reported) are qualitatively similar.

impact on the effective average overnight rate will be stronger than a change of either one of the measures alone; (iv) the effect of a change in the IOER rate is less strong in the case of high non-EA lending bank participation. A high non-EA lender participation reduces the refinancing costs of EA borrowing banks, with the effect being more pronounced the higher the level of the IOER rate is. This shows that looking at an average rate, such as the Eonia[23], that does not take into account the documented money market segmentation can be misleading in assessing euro area banks' individual refinancing costs. This has important implications as Eonia is an important money market reference rate that underlies a large volume of financial derivative contracts and is also an important determinant of short-term retail bank interest rates (e.g., Sorensen and Werner 2006).

In Figure 6, we use our estimated bargaining model to analyze further the implication of the heterogeneity in banks' bargaining power and outside options for monetary policy. We do this by considering the interest rate reaction to monetary policy changes for three different kind of representative bank pairs: (i) a lender with a low lending concentration (lender's HHI is in the 5th percentile) and a borrower with a low borrowing concentration (borrower's HHI is in the 5th percentile); (ii) a lender with a high lending concentration (lender's HHI is in its 95th percentile) and a borrower with a low borrowing concentration (borrower's HHI is in the 5th percentile); (iii) a lender with a low lending concentration (lender's HHI is in the 5th percentile) and a borrower with a high borrowing concentration (borrower's HHI is in the 95th percentile). [24]We analyze this type of heterogeneity at the bank-pair level for both the non-EA-lender-to-EA-borrower and EA-lender-to-EA-borrower pairs separately.

Our results show that the group of EA-to-EA bank pairs exhibits a strong heterogeneity in bargaining power, in particular, for lenders with a low lending concentration providing credit to borrowers with a high borrowing concentration exhibiting the strongest bargaining power. Heterogeneous bargaining effects are, however, less pronounced when many excess reserves are held in the euro area banking sector. But, if the level of excess reserves decreases to zero (or close to zero as it was before the financial crisis) the lenders' bargaining power increases for all groups. In addition, we find that the within-group heterogeneity increases substantially. For example, the bargaining power of high HHI borrowers when borrowing from low HHI lenders is about 0.1 smaller than that of low HHI borrowers. With an interest rate

[23] In the euro area, the Eonia is based on transactions from a panel of 35 selected banks, see www.euribor.org. Non-EA lenders are under-represented (or not included at all) in this computation, hence suggesting that the Eonia is upward biased and does not reflect the actual price of overnight funds for euro area banks.

[24] These three stylized pairs correspond to the empirically relevant situation that we know from the 'core-periphery' interbank network topology context, where two very active banks in the interbank market engage with each other (case (i)), or one of the counterparties is very active and well connected, whole the counterparty is not (cases (ii) and (iii)).

corridor width of, say 1.5 percent, this corresponds to a 15 basis point difference. Figure 6 also shows that the documented effects are quantitatively similar in a situation when the Eurosystem abolishes its fixed-rate full allotment policy in favor of the variable rate tender with a price discriminatory auction setup (dashed lines).

For non-EA-lenders-to-EA-borrowers bank pairs, we find qualitatively similar results regarding the heterogeneity in bargaining power but document quantitatively less within-group heterogeneity as compared to EA-lender-to-EA-borrower pairs. Moreover, the bargaining power of non-EA lenders reacts more strongly to changes in monetary policy measures. First, a reduction in excess reserves leads to a stronger increase in bargaining power than for EA lenders for all three different bank pairs. Second, the within-group heterogeneity in bargaining power actually diminishes once excess reserves are reduced to zero. Third, abolishing the fixed-rate, full-allotment policy would shift the bargaining power toward non-EA lenders by about 0.2. In economic terms, in a world without the fixed-rate full-allotment policy the interest rate at which non-EA banks lend out overnight funds to EA banks would be higher by about 30 basis points.

Overall, our analysis shows that the heterogeneity in both banks' bargaining power and outside options has important implications for the transmission of monetary policy on the first stage, i.e. to banks' individual short-term refinancing costs. Measurement concepts such as Eonia do not capture the heterogeneity in individual banks' liquidity and refinancing costs. Policy makers should take these heterogeneous effects into account when assessing the interest rate pass-through in the euro area.

V. CONCLUSION

When implementing monetary policy, many central banks place a lot of weight on average short-term interest rate measures (such as Eonia). However, we argue in this paper that the interest rates in the over-the-counter interbank market may vary strongly across market participants depending on different outside options and especially *bilateral bargaining power* of both the lender and the borrower of a given trade, thereby affecting monetary policy implementation and its transmission to the wider economy.

We use a proprietary dataset on the euro area interbank market to establish the following robust key results. We find that (i) lenders with greater bargaining power than their borrowers are able to negotiate higher interest rates, (ii) lenders with outside options (i.e., access to the Eurosystem's facilities) charge higher interest rates (on average by about 10 basis points) for overnight loans than their peers without such an access, (iii) the negotiated interest rates are more sensitive to the bargaining power of the lender bank if the lending institution has no outside investment option, and (iv) interest rates can fall below the Eurosystem's IOER rate if the bargaining power of the lender is sufficiently small and the lender has no outside options. Persistent arbitrage opportunity can only arise when these banks persistently provide funds at a rate below the IOER rate, inducing a segmentation of prices for central bank reserves in the euro interbank market.

As a consequence of this segmentation in interbank rates, some banks face substantially different refinancing cost than suggested by the official average effective overnight rate (Eonia), thereby affecting the transmission of monetary policy. In particular, going forward, our results suggest that the bank-individual effects of any policy related to a tightening of euro area monetary policy stance—either through an unwinding of unconventional policy or through an interest rate increase—should be expected to depend on banks' alternative outside options and especially bilateral bargaining power of participating banks at that time in the interbank market. Indeed, our analysis shows that a substantial participation of banks without access to the IOER facility will put downward pressure on interbank rates when the IOER is moved back into positive territory (and different outside options become relevant). On the other hand, the reduction of the large amount of excess reserves will shift bargaining power from borrowers toward lender banks and thus increase interbank rates.

More generally, our finding that interbank rates vary substantially depending on bilateral bargaining power suggests that for the transmission of monetary policy it is important to consider the variation of refinancing cost in the interbank market across different banks using transaction-level data. Our findings could possibly also be relevant for determining the perimeter of counterparties eligible for central bank monetary operations as the bargaining power of direct counterparties (such as the primary dealers in the United States versus a wider set of eligible counterparties, e.g., in the euro area) will affect the pass-through of monetary policy measures to broader financial markets and the economy. These results are also important as they reveal that the effect of bilateral bargaining power is important irrespective of the prevailing monetary policy implementation framework, i.e., reserve regime (e.g., U.S. Fed, Bank of Japan) versus an interest rate corridor regime (e.g., ECB, Bank of England).

Finally, our results could inform the discussion about the size of central banks' balance sheets when policy rates move away from their current low levels. In case the central bank intends to minimize the cross-sectional dispersion of bilateral interbank interest rates, our findings suggest that a floor system – which requires a larger than needed central bank balance sheet – could be an option worthwhile considering,[25] because the impact of heterogeneity in bargaining power on the pricing of interbank loans decreases when the supply of central bank reserves is large. In this context, it is moreover noted that a broad access policy with regard to remunerated deposits with the central bank tends to provide an outside option for banks, which in turn contributes to limiting the dispersion of rates.

[25] Other options to steer the cross-sectional dispersion of short-term interbank rates might include the width of the interest rate corridor.and the allotment modalities of tender operations.

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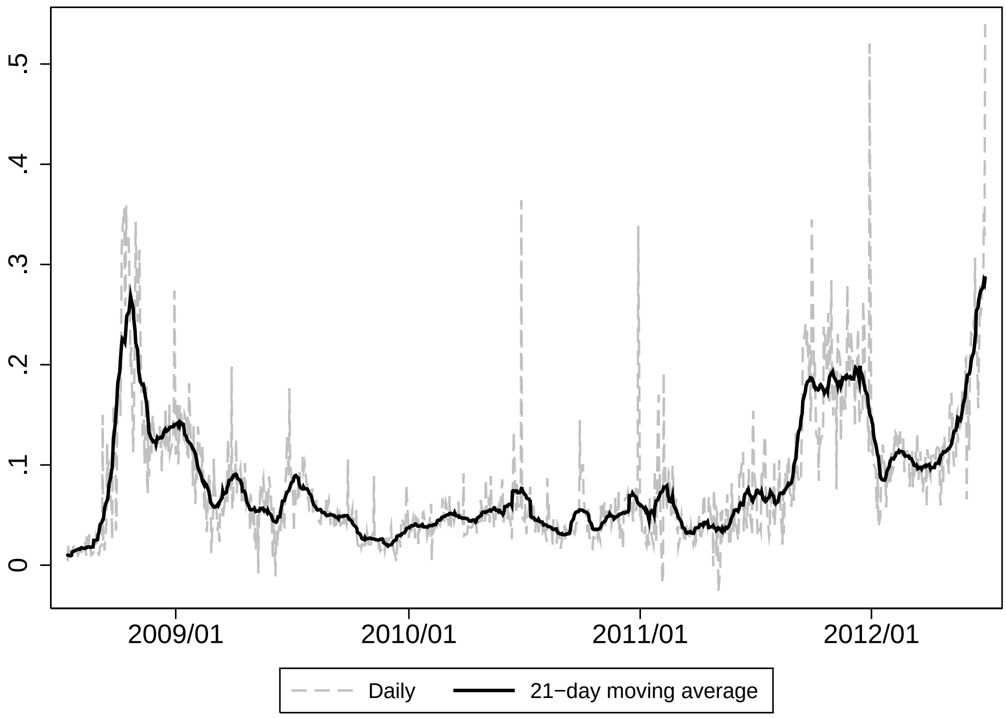
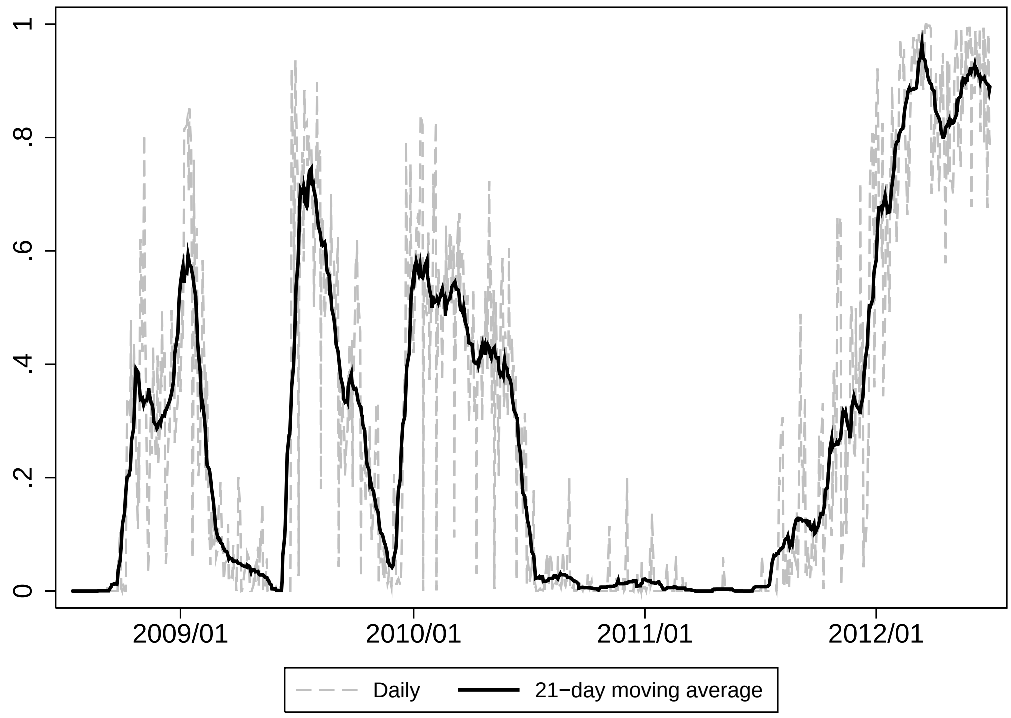
FIGURES

FIGURE 1: INTEREST RATE SPREAD BETWEEN EA AND NON-EA LENDERS



Note: This figure depicts the daily (equally weighted) average spread (gray dashed line, in percent) between the interest rates that EA lending and non-EA lending banks charge for an overnight credit during the sample from 2008/07/01 through June 2012/06/29. It also shows the 21-day moving average (black solid line) spread.

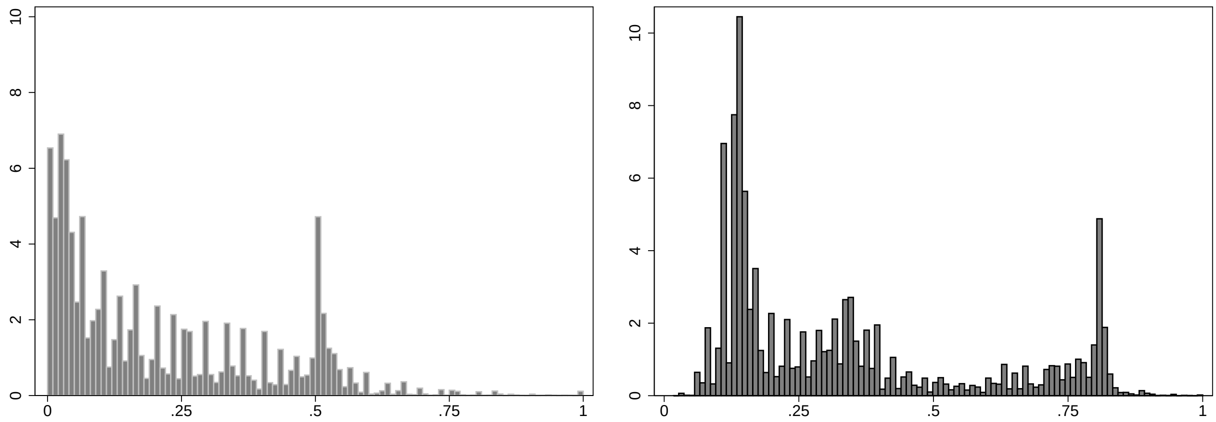
FIGURE 2: FRACTION OF TRADES BELOW THE IOER RATE



Note: This figure presents the evolution of EA lenders' daily total loan amount lent at rates below the IOER rate as a fraction of their daily total loan amount (gray dashed line) in our sample from 2008/07/01 through June 2012/06/29. It also shows the 21-day moving average (black solid line).

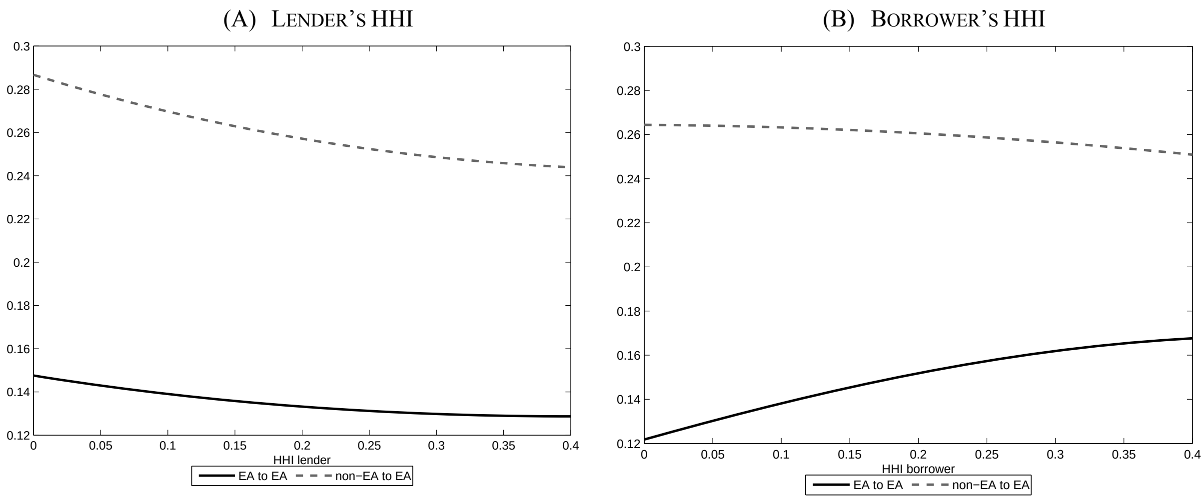
FIGURE 3: HISTOGRAM OF LENDER BARGAINING POWER AT THE BANK-PAIR LEVEL

(A) EA LENDING BANKS (B) NON-EA LENDING BANKS



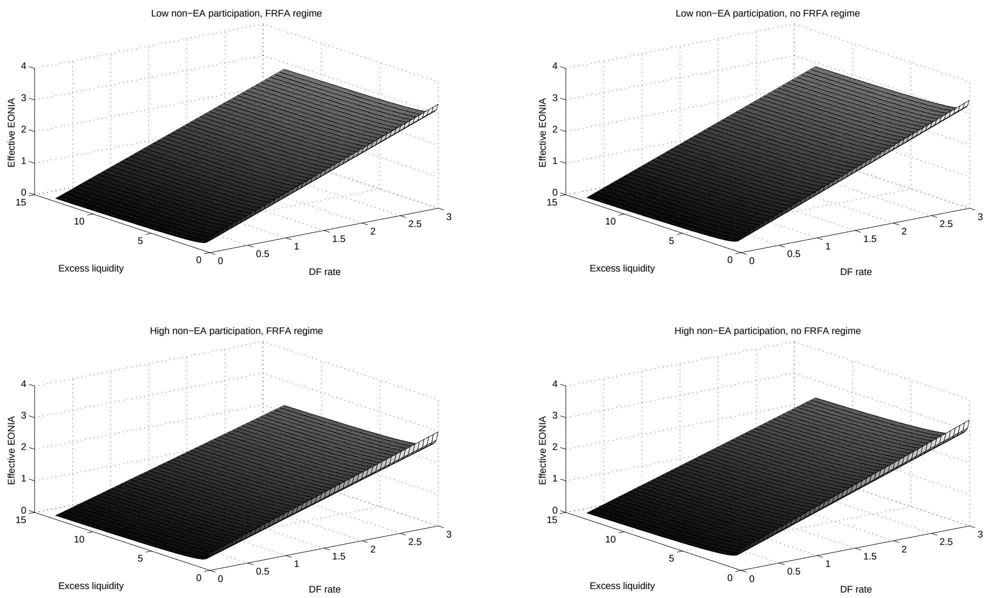
Note: Subfigure (a) shows the histogram of the (equally weighted) average of the bilateral bargaining power, $\theta_{i,j,t}$ of EA lending banks in our sample from 2008/07/01 through June 2012/06/29. Subfigure (b) reflects the histogram of the (equally weighted) average of the bilateral bargaining power of non-EA lending banks for the same sample.

FIGURE 4: IMPACT OF LENDER’S AND BORROWER’S CONCENTRATION ON LENDER BARGAINING POWER



Note: Subfigure (a) refers to the estimated effect of the lender’s HHI on the lender bargaining power ($\theta_{i,j,t}$) presented in column 2 and 4 of Table 5. The black solid line refers to the sample of loans between EA lender and EA borrower (column 2) and the gray dashed line is based on the sample of loans between non-EA lender and EA borrower (column 4). Subfigure (b) reflects the estimated effect of the borrower’s HHI on the lender bargaining power ($\theta_{i,j,t}$) presented in column 2 and 4 of Table 5. The black solid line refers to the sample of loans between EA lender and EA borrower (column 2) and the gray dashed line is based on the sample of loans between non-EA lender and EA borrower (column 4).

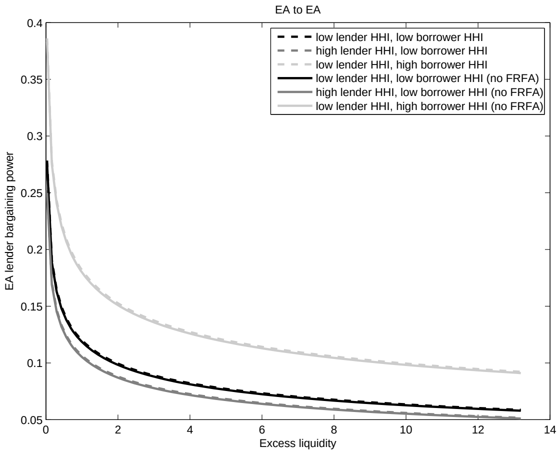
FIGURE 5: POSSIBLE OUTCOMES FOR THE EFFECTIVE EUROPEAN OVERNIGHT RATE IN RESPONSE TO MONETARY POLICY CHANGES



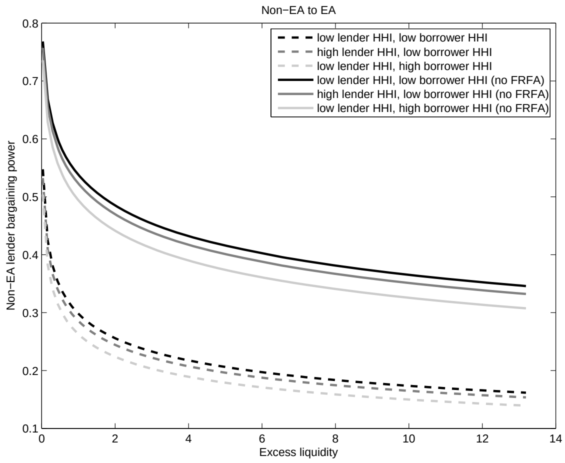
Note: This figure presents the set of possible outcomes for the effective European overnight rate, Eonia, (z-axis, in percent) in response to monetary policy changes, e.g., changes in the excess reserves (y-axis, in logarithm of billion Euros) available to the banking sector, changes in the IOER rate (x-axis, in percent), and a potential switch from the fixed-rate full allotment policy to a variable rate tender with price discrimination. The possible set of outcomes of the effective overnight rate is constructed for four different cases: (i) low non-EA participation under FRFA regime (upper left panel) , (ii) low non-EA participation and abolishing FRFA regime (upper right panel), (iii) high non-EA participation under FRFA regime (lower left panel) , (ii) high non-EA participation and abolishing FRFA regime (lower right panel).

FIGURE 6: CHANGES OF LENDER BARGAINING POWER IN RESPONSE TO MONETARY POLICY CHANGES

(A) EA LENDER TO EA BORROWER



(B) NON-EA LENDER TO EA BORROWER



Note: Subfigure (a) shows how the bargaining power of the EA lender changes in response to monetary policy changes, e.g.,. changes in the excess reserves provided by the Eurosystem and abolishing the FRFA policy. Subfigure (b) presents how the bargaining power of the non-EA lender changes in response to monetary policy changes, e.g., changes in the excess reserves provided by the Eurosystem and abolishing the FRFA policy.

TABLES

TABLE 1 – SUMMARY STATISTICS

Loan characteristics of EA lending banks:	Mean	Std.	p5%	p95%
Rate - IOER	0.317	0.323	0.010	1.030
Amount	10.332	1.394	8.517	12.766
Theta	0.199	0.191	0.007	0.550
Lender's HHI	0.152	0.163	0.008	0.506
Lender's HHI^2	0.049	0.108	0.000	0.256
Borrower's HHI	0.152	0.182	0.005	0.555
Borrower's HHI^2	0.056	0.131	0.000	0.308
Loan characteristics of non-EA lending banks:	Mean	Std.	p5%	p95%
Rate - IOER	0.164	0.309	-0.100	0.990
Amount	10.885	1.331	8.700	13.102
Theta	0.320	0.230	0.111	0.810
Lender's HHI	0.243	0.204	0.016	0.642
Lender's HHI^2	0.101	0.154	0.000	0.412
Borrower's HHI	0.118	0.162	0.003	0.481
Borrower's HHI^2	0.040	0.110	0.000	0.231
Interbank market characteristics	Mean	Std.	p5%	p95%
IOER	0.663	0.863	0.250	3.250
Marginal lending facility	2.191	0.884	1.750	4.250
Corridor width	1.528	0.220	1.000	2.000
Fraction non-EA trades	0.226	0.067	0.129	0.337
Fraction non-EA trades below IOER rate	0.334	0.328	0.000	0.900
Amount outstanding associated with OMOs (in logs)	6.434	0.275	6.034	6.888
FRFA_dummy	0.946	0.226	0.000	1.000
Excess reserves (in logs)	18.239	1.702	16.033	20.459
Fraction reserve holdings	0.002	0.013	0.000	0.009
FX, bond, and equity market liquidity	0.068	0.307	-0.590	0.340
Money market liquidity	-1.189	1.316	-4.220	0.050
Last day of RMP	0.051	0.220	0.000	1.000

Note: This table provides summary statistics on all main variables used in the paper covering the period from 2008/07/01 through June 2012/06/29. In the upper panel of the table, we provide loan level information on trades where the lending bank is a EA bank. In the middle panel, we provide the same information on non-EA lending banks. In the bottom panel, we provide descriptive statistics on market-wide characteristics. A definition of our main variables is provided in the Appendix Table A1

TABLE 2 – BARGAINING POWER, OUTSIDE OPTIONS, AND BILATERAL INTEREST RATES

	Dependent Variable: Rate - IOER						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Corridor width	49.815***	31.229***	30.978***	31.121***			
	(0.25)	(0.20)	(0.19)	(0.19)			
IOER rate		14.330***	14.314***	14.271***			
		(0.04)	(0.04)	(0.04)			
Dummy (Non-EA to EA)			-15.157***	-14.342***	-10.247***	-10.301***	
			(0.10)	(0.10)	(0.05)	(0.05)	
Lender's HHI				-8.230***	-3.984***	-3.562***	1.909***
				(0.30)	(0.18)	(0.20)	(0.22)
Borrower's HHI				1.935***	12.262***	11.930***	0.832***
				(0.34)	(0.23)	(0.22)	(0.25)
Lender's HHI*Dummy (Non-EA to EA)						-2.605***	-4.442***
						(0.35)	(0.40)
Borrower's HHI*Dummy (Non-EA to EA)						-15.610***	-4.173***
						(0.48)	(0.51)
RMP fixed effects	Yes	Yes	Yes	Yes	-	-	-
Loan amount control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	No	No	No	No	Yes	Yes	Yes
Bank-pair fixed effects	No	No	No	No	No	No	Yes
Observations	371,805	371,805	371,805	371,805	371,805	371,805	371,805
R-squared	0.150	0.342	0.378	0.379	0.826	0.827	0.899

Note: This table reports the least squares estimates of Equation 2. The dependent variable is the spread between the bilaterally negotiated interest rate of the loan between lender i and borrower j at day t and the IOER facility rate (IOER rate) on the same day (in basis points). Robust standard errors are presented in parentheses. The definition of all variables can be found in Table A1.

TABLE 3 – BARGAINING POWER, OUTSIDE OPTIONS, AND BELOW-IOER TRADES

	Dependent Variable: Below IOER Rate (0/1)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Corridor width	-0.092***	-0.082***	-0.077***	-0.078***			
	(0.00)	(0.00)	(0.00)	(0.00)			
IOER rate		-0.007***	-0.007***	-0.006***			
		(0.00)	(0.00)	(0.00)			
Dummy (Non-EA to EA)			0.314***	0.307***	0.291***	0.284***	
			(0.00)	(0.00)	(0.00)	(0.00)	
Lender's HHI				0.092***	0.067***	0.035***	-0.039***
				(0.00)	(0.00)	(0.00)	(0.00)
Borrower's HHI				0.044***	0.009***	0.013***	0.042***
				(0.00)	(0.00)	(0.00)	(0.00)
Lender's HHI*Dummy (Non-EA to EA)						0.230***	0.114***
						(0.01)	(0.01)
Borrower's HHI*Dummy (Non-EA to EA)						0.210***	0.339***
						(0.01)	(0.02)
RMP fixed effects	Yes	Yes	Yes	Yes	-	-	-
Loan amount control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	No	No	No	No	Yes	Yes	Yes
Bank-pair fixed effects	No	No	No	No	No	No	Yes
Observations	371,805	371,805	371,805	371,805	371,805	371,805	371,805
R-squared	0.010	0.011	0.273	0.276	0.343	0.349	0.557

Note: The estimations presented in this table refer to Equation 3. The dependent variable is a binary variable that equals one for any loan between lender i and borrower j at day t that is traded at an interest rate below the IOER rate, and zero otherwise. Robust standard errors are presented in parentheses. The definition of all variables can be found in Table A1.

TABLE 4 – BELOW-IOER TRADES AND RECOURSE TO IOER FACILITY

	Dependent Variable: Excess Reserves Held at IOER Facility				
	Pooled OLS				IV regression
	(1)	(2)	(3)	(4)	(5)
Loan amount borrowed below IEOR rate	0.546***	0.487***	0.279***	0.252***	0.365***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Loan amount borrowed above IOER rate	-0.020***	0.023***	-0.154***	-0.150***	-0.058***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
(Rate - IOER) for borrowing below-IOER-rate				-2.813***	-1.582***
				(0.39)	(0.39)
(Rate - IOER) for borrowing above-IOER-rate				0.229***	-0.161***
				(0.05)	(0.05)
RMP fixed effects	Yes	-	-	-	-
Loan amount lent control	Yes	Yes	Yes	Yes	Yes
Time fixed effects	No	Yes	Yes	Yes	Yes
Bank-pair fixed effects	No	No	Yes	Yes	Yes
Observation	87,431	87,431	87,431	87,431	87,431
R-squared	0.215	0.289	0.443	0.444	0.396

Note: This table shows the least squares estimates of Equation 4. The dependent variable is the (logarithm of) the amount parked at the IOER facility by bank j at day t. 'Loan amount borrowed below (above) IEOR rate' is the (logarithm) of the amount borrowed below (above) the IOER rate by bank j on day t. Robust standard errors are presented in parentheses. The definition of all variables can be found in Table A1.

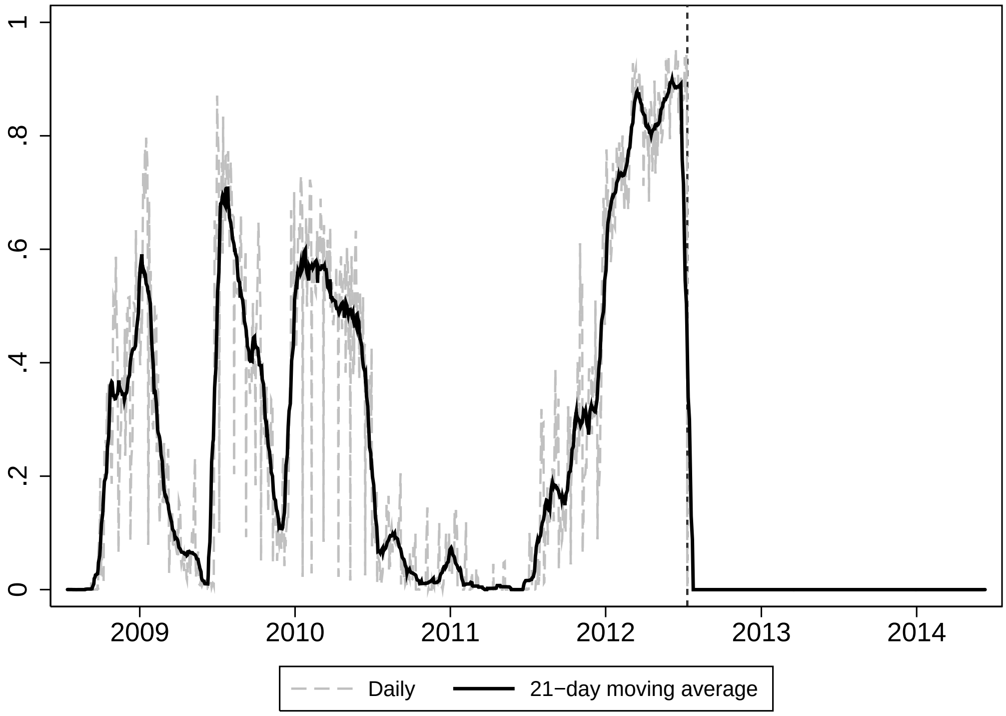
TABLE 5 – DETERMINANTS OF BILATERAL BARGAINING POWER

	Dependent Variable: Theta							
	EA lending banks				Non-EA lending banks			
	Coef.	ME	Coef.	ME	Coef.	ME	Coef.	ME
	(1)	(1')	(2)	(2')	(3)	(3')	(4)	(4')
Lender's HHI	-0.256***	-0.036***	-0.791***	-0.111***	-0.278***	-0.058***	-0.939***	-0.195***
	(0.02)	(0.00)	(0.04)	(0.01)	(0.01)	(0.00)	(0.03)	(0.01)
Borrowers's HHI	0.594***	0.084***	1.638***	0.230***	-0.245***	-0.051***	-0.010	-0.002
	(0.02)	(0.00)	(0.04)	(0.01)	(0.02)	(0.00)	(0.04)	(0.01)
Lender's HHI^2			0.988***	0.139***			0.979***	0.204***
			(0.07)	(0.01)			(0.05)	(0.01)
Borrowers's HHI^2			-1.738***	-0.245***			-0.420***	-0.087***
			(0.06)	(0.01)			(0.07)	(0.02)
Amount outstanding associated with OMOs	-1.910***	-0.269***	-1.923***	-0.271***	-0.755***	-0.157***	-0.752***	-0.156***
	(0.02)	(0.00)	(0.02)	(0.00)	(0.02)	(0.00)	(0.02)	(0.00)
FRFA dummy	0.030**	0.004**	0.021*	0.003*	-1.012***	-0.236***	-1.008***	-0.235***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Excess reserves (in logs)	-0.305***	-0.043***	-0.306***	-0.043***	-0.311***	-0.065***	-0.311***	-0.065***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fraction reserve holdings	-7.609***	-1.072***	-7.180***	-1.010***	-3.359***	-0.699***	-3.286***	-0.684***
	(0.50)	(0.07)	(0.51)	(0.07)	(0.14)	(0.03)	(0.14)	(0.03)
FX, bond, and equity market liquidity	-0.688***	-0.097***	-0.698***	-0.098***	-1.099***	-0.229***	-1.098***	-0.228***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Money market liquidity	-0.204***	-0.029***	-0.204***	-0.029***	-0.371***	-0.077***	-0.372***	-0.077***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Last day of RMP	0.546***	0.089***	0.556***	0.091***	0.544***	0.123***	0.545***	0.123***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Observations	291,163		291,163		80,642		80,642	

Note: This table repots coefficient estimates of Equation 5 along with marginal effects. The dependent variable is a non-linear transformation of a linear index function that can take on values between zero and one. It measures the bilateral bargaining power between lender i and borrower j at day t. For each model the first column presents the parameter estimates, the second column (prime) the marginal effects at the mean. The sample is restricted to those loans where the lending bank is a euro area bank. Robust standard errors are presented in parentheses. The definition of all variables can be found in Table A1.

APPENDIX

FIGURE A1 – FRACTION OF TRADES BELOW THE IOER RATE
BEFORE AND AFTER IOER RATE WAS SET TO ZERO



Note: This figure presents the evolution of non-EA lenders' daily total loan amount lent at rates below the IOER rate as a fraction of their daily total loan amount (gray dashed line) in our sample from 2008/07/01 through June 2014. It also shows the 21-day moving average (black solid line). The dashed vertical line represents July 11, 2012 when the Eurosystem set its IOER rate to 0 percent.

TABLE A1 – DEFINITION OF VARIABLES

Variable	Definition
$Rate_{i,j,t}$	Interest rate (in percent) of overnight loan between lender bank i and borrower bank j at day t.
Below IOER $Rate_{i,j,t}$ (0/1)	Dummy variable that equals the value of one if the overnight loan between lender bank i and borrower bank j at day t is traded at a rate below the IOER rate of the same day t, and zero otherwise.
Dummy $(Non\text{-}EA\ to\ EA)_{i,j}$	Dummy variable that equals the value of one if for any given bank-pair the lender bank is from a non-EA country and the borrower bank is from an EA country, and zero otherwise.
IOER $rate_t$	Interest rate (in percent) at which the ECB remunerates excess reserves held in the IOER facility prevailing at day t.
Corridor $width_t$	Difference between the marginal lending facility (in percent) and the IOER rate (in percent) of the ECB prevailing at time t.
Lender's $HHI_{i,t}$	Equals the sum of the squared bank-pair lending shares of lender bank i with respect to all other banks on day t, computed based on the its lending activity during the last 30 days .
Borrower's $HHI_{j,t}$	Equals the sum of the squared bank-pair borrowing shares of borrower bank j with respect to all other banks on day t, computed based on the its borrowing activity during the last 30 days.
Open market $operations_t$	Logarithm of total amount (in EUR thousands) outstanding associated with open market operations (main refinancing operations and longer-term refinancing operations).
FRFA $dummy_t$	Dummy that equals the value of one for all days after October 15, 2008, i.e., when the Eurosystem introduced the fix-rate full allotment policy, and zero otherwise.
Excess $reserves_t$	Logarithm of total amount (in EUR thousands) of excess reserves held by all banks at the IOER facility of the Eurosystem at day t.
Excess Reserves Held at IOER $Facility_{j,t}$	Logarithm of total amount (in EUR million) of excess reserves held by individual bank i at the IOER facility of the Eurosystem at day t.
Fraction reserve $holdings_t$	Share of total excess reserves at the IOER facility of the Eurosystem held by bank i at day t.
Last day of RMP_t	Dummy that equals the value one if day \$t\$ is the last day of a reserve maintenance period.
Money market $liquidity_t$	Index that measures the liquidity in money markets, higher values indicate more liquid markets, see Box , Financial Stability Review, ECB, June 2007.
General financial market $liquidity_t$	Index that measures the liquidity in FX, bond, and equity markets, higher values indicate more liquid markets, see Box , Financial Stability Review, ECB, June 2007.