Monetary policy disconnect

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Abstract

We analyze the continuous transmission of monetary policy focusing on its first step, the pass-through via the main short-term money market, the repurchase agreement (repo) market. Two crucial aspects of the central bank framework hinder this transmission. First, lending rates of banks with access to the deposit facility are less responsive to changes in the monetary policy rate. Second, repo rates secured by assets eligible for Quantitative Easing (QE) are more disconnected from the policy rate. We show that both effects create rate dispersion and add to one another in weakening the monetary policy transmission into the real sector.

Keywords: Monetary policy, Disconnect, Interest rate pass-through, Money market, Central bank framework, Deposit facility, Quantitative Easing

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“...there is a risk that, under the current framework, some short-term market rates would \textbf{not respond fully} to changes in our key interest rates or, even if they would, that a continued dispersion of short-term rates would \textbf{adversely impact} the transmission of our monetary policy stance.”

—Benoît Cœuré in May 2018

An important question at the center of the political and academic debate is what makes the transmission of monetary policy effective. The monetary policy transmission process involves three main steps: (i) The central bank’s monetary policy actions pass through into the money market; (ii) the conditions in the money market impact debt and equity markets and (iii) ultimately propagate into the goods market and real sector. To evaluate the effectiveness of monetary policy, we therefore need to consider the money market which “plays a crucial part in the transmission of monetary policy decisions” as “changes in the monetary policy instruments affect the money market first” \cite{EuropeanCentralBank2011}. In outlining its monetary policy framework, the European Central Bank (ECB) also emphasizes that “a deep and integrated money market is a precondition for an efficient monetary policy, since it ensures an even distribution of central bank liquidity and a homogeneous level of short-term interest rates.” However, institutional and political features of the central bank framework can generate dispersed money market rates raising the risk of central banks losing control over short-term interest rates \cite{Coeure2019}.

The first step of the monetary policy transmission into the money market is the main focus of this paper as we provide the first empirical study evaluating the continuous, immediate reaction of money market rates to monetary policy changes. For this, we consider the EONIA rate which is the operational target rate of the ECB as our main monetary policy measure\footnote{In the following, when we refer to the monetary policy rate, we refer to this operational target rate of the ECB.}. We show that two key aspects of the central bank framework that were designed to support the monetary policy transmission can actually \textit{disconnect} it. To do this, we analyze how two
elements of the monetary policy framework affect the main short-term funding market, the repurchase agreement (repo) market.\footnote{A repo is a short-term loan (over-)collateralized by a government bond.} The first hurdle for the monetary policy transmission stems from the access to the central bank’s refinancing operations and its deposit facility. We demonstrate that the lending rates of banks with access to the central bank’s facilities are less responsive to the monetary policy rate, especially when money market rates are below the central bank’s deposit rate discouraging interbank lending. The second hurdle emanates from unconventional measures such as Quantitative Easing (QE) targeting the purchase of only certain assets and creating their scarcity. We show that short-term rates secured by assets eligible for QE programs diverge more from the monetary policy rate. Both effects lead to rate dispersion, market segmentation and add to one another, suggesting a joint impact in weakening the monetary policy transmission, that ultimately leads to a weaker reaction of real sector rates to changes in monetary policy.

The ideal laboratory to examine this idea is the ECB and the repo market: Firstly, with a size of more than EUR 7.5 trillion in outstanding contracts\footnote{The euro repo market is now 20 times bigger than the unsecured segment.} the European repo market is the largest repo market worldwide and, secondly, it is the main source of funding liquidity in the Euroarea.\footnote{Thus, the repo market is key for an efficient allocation of money and assets. In addition, the repo rate acts as a benchmark in financial markets.} Finally, the market infrastructure features central clearing and anonymous centralized order book platforms, which ensures homogeneous counterparty risk and collateral policy, no bargaining power, and an efficient price formation process.

For our analysis, we employ a unique and highly representative data set for the entire Euro repo market including all repos exchanged on the three major trading platforms (BrokerTec, Eurex, and MTS) from 2010 to 2020 covering more than 70% of the entire repo market universe.\footnote{The asset being used as collateral in a repo transaction can be a particular asset (“special repo”) or any asset from a predefined basket of assets (“general collateral or GC repo”). The GC market is generally more funding-driven while the special repo market is more collateral-driven. Our data set covers both market segments.} Our results are therefore highly representative and thus relevant for central banks and market participants as unresponsive short-term rates limit the central bank’s ability to
fulfill its mandate (European Central Bank, 2011).

The first key aspect of a central bank’s institutional framework that we investigate is that only a given set of banks have exclusive access to the ECB refinancing operations and its deposit facility. Here, we focus on the general collateral (GC) segment of the repo market. In the wake of a negative supply shock, when fewer banks need to borrow liquidity, GC rates decrease and can fall below the deposit facility rate (DFR). Rather than encouraging interbank lending, this creates an incentive to deposit liquidity at the central bank for banks that have the opportunity to do so. We identify which banks benefit from access to the deposit facility and at which rate they lend in the GC interbank market and observe that the share of access banks’ lending decreased when GC rates fell below the rate on the deposit facility. During those periods, access banks tend to lend at higher rates than nonaccess banks pointing to a more segmented repo market. Hence, our first testing hypothesis for the monetary policy disconnect is that banks with (without) access to the ECB’s deposit facility lend at repo rates less (more) aligned to the monetary policy target rate, in particular when money market rates are below the DFR.

To test this first hypothesis, we perform a comprehensive panel regression analysis. For this, we regress (changes in) GC repo rates on (changes in) the monetary policy rate interacted with a dummy variable indicating a bank’s access to the deposit facility to determine systematic differences between access and nonaccess banks. We clearly find that access banks respond less to changes in monetary policy, in particular when repo rates are below the DFR corroborating the monetary policy disconnect featured by those banks. In addition to the statistical significance, our findings appear economically relevant. For instance, a more accommodative monetary policy that results in a decrease in the target rate by one percentage point translates into a decrease in GC rates involving access banks of 45 basis points. For banks without access, the decrease is 72 basis points. Once GC rates are below the DFR, the effect magnifies as the rates of nonaccess banks decrease by 94 basis points (pointing to an almost one-to-one pass-through) while the rates of access banks only decrease by 4 basis points (pointing to an almost muted pass-through). We illustrate our mechanism by showing
that the reaction of access banks to changes in the target rate gets weaker the closer money market rates get to and fall below the DFR.

To provide evidence of the causal impact of the convenience of the deposit facility on the weaker reaction of access banks to changes in monetary policy, we consider the introduction of the ECB’s two-tier system for remunerating excess reserve holdings in 2019 as a natural experiment. The introduction exempted part of the excess reserve holdings held by access banks from negative rates. This created an even stronger incentive for access banks to store funds at the deposit facility. As a result, the reactiveness of access banks to monetary policy weakened.

The second key aspect of the policy framework that we consider are the eligibility criteria of the QE program. For this part, we focus on the “special” segment of the repo market. The trading volume in the special market has increased since the start of QE, predominantly driven by transactions collateralized with assets eligible for central bank purchases. Repos secured by eligible assets tend to trade at lower rates compared to noneligible assets (Arrata et al., 2020; Corradin and Maddaloni, 2020). As a consequence, the specialness premium of eligible assets increases and the repo rates secured by eligible assets become predominantly driven by collateral demand disconnecting them from the policy rate. This wedge between eligible and noneligible assets is an unintended consequence of QE and leads to a second form of segmentation in the repo market. Our second testing hypothesis is therefore that rates of repos whose collateral asset is (not) eligible for QE programs are less (more) responsive to the monetary policy rate.

For the empirical analysis, we regress (changes in) special repo rates on (changes in) the monetary policy rate interacted with a dummy variable indicating whether an asset is eligible for QE purchases. We also apply the initial implementation provisions retrospectively to compare time trends between (hypothetically) eligible and noneligible assets, which creates a difference-in-difference estimation setting. We find that in the period after the introduction of QE, a loose monetary policy with a decrease of the target rate by one percentage point is associated with a 50% lower sensitivity of eligible assets relative to the overall sensitivity of
special repo rates to changes in funding conditions. We observe a similar behavior of (hypothetically) eligible and noneligible assets in the periods prior to QE and diverging patterns during QE, suggesting a causal impact of central bank asset purchases on the monetary policy disconnect. To underline the importance of asset scarcity in this mechanism, we show that an asset’s sensitivity to the monetary policy rate decreases with the time an asset is eligible for QE purchases.

We also consider the combined effect of access to the central bank’s facilities and QE eligibility on the responsiveness of money market rates to changes in monetary policy. We find that when the share of securities eligible for QE programs in a GC basket is large, the GC rate is less reactive to the monetary policy target rate, even after controlling for the effect of bank’s access to the deposit facility. Similarly, when the ‘cheapest-to-deliver’ asset in a basket is eligible for QE, the GC rate of that basket is less responsive. In the special market, we document that repo rates of access banks react less to the monetary policy rate even after accounting for asset eligibility for QE programs. One interpretation of these findings is that asset scarcity associated with QE purchases together with the incentive to hold reserves on the central bank’s deposit facility jointly weigh on the monetary policy pass-through efficiency.

Notice that our setting allows us to take advantage of the legal and technical rules that the Eurosystem imposes to avoid any endogeneity concerns related to reverse causality. In particular, the set of nonaccess banks is constant over our sample period, whether a bank is legally formed in- or outside of the euro area is unrelated to monetary policy and the repo market, and thus a source of exogenous variation. Moreover, both groups feature similar balance sheet characteristics. Similarly, the implementation provisions for asset purchases are a source of exogenous variation regarding which securities are eligible for the QE program.

Instead of considering only specific moments when monetary policy is implemented such as announcements of central bank decisions, our paper provides a novel analysis about the continuous reaction of key money market rates to changes in monetary policy. For this, we consider the short-term interest rate benchmark (EONIA) as our main monetary policy measure. The EONIA is “the key ECB interest rate” ([European Central Bank](https://www.ecb.europa.eu/), 2011) and is
usually referred to as the operational target by the ECB (Cœuré 2018). Still, we show that our results remain statistically and economically consistent if we consider other policy rates that the ECB could possibly target, thus indicating their general validity and dispelling any doubts that they depend on a specific way to measure the monetary policy stance. We further perform a number of other analyses to ensure the comprehensiveness and robustness of our results. We conduct our analyses for (1) different groups of countries including (i) Germany, (ii) core European countries, and (iii) all European countries and (2) different term types; (3) we replicate our panel regression analyses by considering all conceivable combinations of standard error and fixed effect specifications; (4) we remove end of quarter and end of ECB maintenance period days and weeks to ensure that our results are not driven by periodic spikes in money market rates; and (5) we replicate our results for a shorter time period to account for the lower volatility in the EONIA in recent years.

A consistent and uniform response of money market rates to the monetary policy stance is the first sign of an effective pass-through mechanism. By contrast, a “wider dispersion in short-term money market rates” could cause “a reduction in the efficacy and transmission of monetary policy” (Bank for International Settlements 2017, p.32). To dive into the second and third steps of the monetary policy transmission process, we compute a dispersion indicator of repo rates based on Duffie and Krishnamurthy (2016) and show that interest rates relevant for the real economy such as non-financial corporate borrowing and housing rates respond less to changes in monetary policy when the dispersion of money market rates is wider. All this provides suggestive evidence of the crucial role of the repo market as a first step of the monetary policy transmission and that dispersed money market rates hinder it.

Our analysis mainly contributes to two strands of the literature. First, we add to the literature on the effectiveness of monetary policy. The existing literature focuses on the pass-through of monetary policy in the context of specific events, such as announcements or policy changes. For example, Duffie and Krishnamurthy (2016) analyze the pass-through of monetary policy in the United States focusing on the introduction of the reverse repurchase facility and new Basel regulation. Drechsler et al. (2017) consider announced changes to the
target corridor of the fed funds rate and show that the pass-through of the interest rate on excess reserves to the interest paid on saving accounts is imperfect due to market power in deposit markets. This is the first paper focusing on the continuous transmission of monetary policy into the short-term funding market and the first one to show and quantify how this pass-through can be impeded by two key features of the central bank framework, i.e., access to central bank facilities and QE eligibility. More precisely, we study the continuous, day-by-day pass-through which is especially important in unconventional policy regimes such as the one prevalent for the last decade, since the transmission of monetary policy is not confined to specific moments but is the result of a continuous implementation of measures such as QE. We also present a novel analysis on the introduction of the two-tiered reserve system to provide evidence for the causal mechanism.

Second, we contribute to the literature on short-term funding markets. Arrata, Nguyen, Rahmouni-Rousseau, and Vari (2020) and Corradin and Maddaloni (2020) investigate the effects of QE purchases on the level of special repo rates. Other papers analyze the unsecured money market; for instance, Kraenzlin and Nellen (2015) examine market segmentation coming from different access levels to the facilities of the Swiss National Bank and Bech and Klee (2011) evaluate the impact of bargaining power in a segmented and unsecured market in the U.S. The novelty of our analysis is threefold: First, we study the pass-through of monetary policy shocks (as opposed to levels). Second, we analyze the reactiveness of money market rates to monetary policy depending on who lends (access versus nonaccess banks) and which assets secure the loan (eligible or not for QE purchases). And third, we show how the two features of the monetary framework create dispersion and segmentation in the repo market.

5On a macro-wide level, Avouyi-Dovi et al. (2017) find a slowdown of the overall interest rates transmission mechanism, which Al-Eyd and Berkmen (2013) have associated with segmentation along country lines. By analyzing the cointegration between policy rates and banks’ weighted cost of capital, Illes et al. (2019) find that the sensitivity of banks’ average funding costs to policy rates has declined in recent years. Kalemli-Ozcan (2019) analyzes the pass-through in the context of emerging markets. For a detailed literature review on interest rate pass-through, see Andries and Billon (2016) and Horvath et al. (2018).

6Extending Arrata, Nguyen, Rahmouni-Rousseau, and Vari (2020) and Corradin and Maddaloni (2020), we study the QE impact on GC rates (in addition to special repos) and the impact of access to central bank facilities on special repo rates.

7Recent papers on repo rate dispersion in European markets include e.g., Mancini et al. (2016), Boissel et al. (2017), and Ranaldo et al. (2021).
1. Monetary policy transmission

It is worthwhile to start our work by describing the main aspects of the monetary policy transmission process. The “monetary policy transmission pipeline” involves three distinct steps. As a first step, the central bank’s monetary policy actions pass-through into the money market. This first step of the transmission is the main focus of our paper as we evaluate the continuous, immediate reaction of money market rates to monetary policy changes (see section 3). In the second step of the transmission pipeline, the conditions in the money market impact debt and equity markets. Monetary policy changes then propagate into the real sector in the third and final step of the monetary policy transmission process. The last part of this paper, section 5, focuses on the second and third step of the transmission process.

As our main monetary policy measure we consider the short-term interest rate benchmark (EONIA), which is an unsecured, overnight interest rate at which banks lend to each other, it is “the key ECB interest rate” (European Central Bank, 2011). We focus on the EONIA as the monetary policy target rate for three reasons. First, it is usually referred to as the operational target by the ECB (Coeure, 2018) and its comovement with other interest rates has been shown in, for example, Hristov et al. (2014) and Altavilla et al. (2020). Second, the EONIA is a standard choice on interest rate pass-through in the literature (see, e.g., Hristov, Hülsewig, and Wollmershäuser, 2014; Altavilla, Canova, and Ciccarelli, 2020 as well as Ciccarelli, Maddaloni, and Peydró, 2015; all three papers employ the EONIA rate as the ECB’s policy instrument). Furthermore, an unsecured money market rate such as the EONIA or the U.S. federal funds rate are commonly considered as the main policy rule to fulfill the central bank’s mandate, which is well reflected in the widely used Taylor rule (Taylor, 1999). And third, it is much more informative than other key rates set by the ECB. This last point warrants a more detailed discussion.

The ECB sets three key interest rates: The rate on the main refinancing operations and

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8We thank our discussant Olivier Wang for suggesting this metaphor.

9Ciccarelli, Maddaloni, and Peydró (2015) also employ the 3-month Euribor rate and the overnight interest swap rate as robustness checks, which we consider as well.
the rates on the deposit and marginal lending facility. The rates on the deposit and marginal lending facility define the corridor for the EONIA. The two rates do not lend themselves to a pass-through analysis since they only move in infrequent, discrete jumps. Importantly, the deposit facility rate is an exogenous rate set by the ECB and only the amounts deposited at the deposit facility are endogenously determined by banks with access to it. Policy interventions such as QE programs are not reflected in the deposit facility rate, it only changes rarely. The EONIA rate, by contrast, evolves continuously and is an endogenously determined rate which is much more informative to central banks (and market participants) as it also captures, for example, time-varying funding conditions and unconventional monetary policy effects. These aspects make the EONIA rate the most appropriate choice as the monetary policy target rate to assess the continuous transmission of monetary policy. Still, we consider all other conceivable monetary policy rates in Section 4, where we validate our findings based on the EONIA rate.

Given that the EONIA rate is unsecured, one may be concerned that the EONIA rate is exposed to certain factors, such as risk in the banking sector, to which repo rates are not exposed. There are three aspects to consider here: (i) We show that the market participants covered in our study feature similar balance sheet characteristics and risk exposures. Similarly, there is no systematically different exposure of QE eligible and noneligible assets to risks embedded in the EONIA. (ii) We consider exogenous events such as the introduction of the ECB tiering system and QE to document our mechanism. (iii) The robustness check employing the rate on the ECB GC pooling basket is not exposed to similar factors and

10 The evolution of the EONIA within the corridor is depicted in the Appendix in Figure A.1.1. Within the corridor, the ECB steers the short-run liquidity conditions with its open market operations by providing liquidity for a period of one week or three months. Although these transactions are secured, open market operations are distinct from regular repo transactions in three ways: First, open market operations are conducted via fixed-rate full-allotment or benchmark allotment auctions, which are executed at the same rate for all participants. Second, these auctions occur on a weekly to monthly basis and thus do not provide for a viable alternative to obtain day-to-day short-term funding. And third, the maturities of one week or three months are longer term than typical overnight repo transactions.

11 In particular, the period studied involves a transition in the economy’s benchmark interest rate. The ECB has chosen the ESTR rate, an unsecured rate, as the new short-term interest rate benchmark to replace the EONIA rate, thereby highlighting the ECB’s renewed commitment to an unsecured target rate. We show that our results are valid for the EONIA in the prior benchmark’s period and for the ESTR since its inception. In addition, to account for monetary policy not being centered around one (unsecured) interest rate, we employ different policy rates such as derivative-based measures and the rate on the ECB GC pooling basket.
confirms our results. We thereby also ensure that the monetary policy disconnect stems from institutional aspects of the central bank framework, in particular a segmentation between access and nonaccess banks or eligible and noneligible assets, as opposed to a segmentation between the secured and unsecured market.

2. Repo market

![Figure 1: Different market turnovers](image)

The first step of the monetary policy transmission process relies on the linkage between monetary policy and the money market. Changes in the monetary policy affect the money market first. The most important instrument used in money markets is the repo, which represents the main short-term funding market for banks. The repo market is now the...
predominant source of funding liquidity and is therefore key for the central bank’s monetary abilities.\textsuperscript{12} Figure 1 illustrates that trading in the European money market has moved towards the secured market segment since the Global Financial Crisis. To put this into perspective, repo trading volume by far exceeds, for example, volumes of cumulative purchases of the largest ECB QE program, the Public Sector Purchase Program (PSPP) or of the ECB’s main refinancing operations. Moreover, according to the Euro Money Market Survey, the size of the secured market is about twenty times the size of the unsecured market.\textsuperscript{13}

In the repo market, two counterparts exchange cash for collateral for a predefined time period with a fixed repurchase obligation. The asset being used as collateral can be a particular asset ("special repo")\textsuperscript{14} or any asset from a predefined basket of assets ("general collateral or GC repo"). The lender in a repo transaction provides a short-term loan (over-)collateralized by a sovereign bond and thus benefits from the ability to use the collateral (convenience) for the time between the purchase and repurchase.\textsuperscript{15} The GC market is generally more funding-driven while the special repo market is more collateral-driven. However, in each transaction there is always a funding motive on the part of the borrower.

The European market infrastructure features (i) central clearing, (ii) anonymous electronic order book trading, and (iii) a large variety of eligible collateral.\textsuperscript{16} Figure 2 shows the repo rate development for GC rates as well as for the average repo rate.

\textsuperscript{12}The influence of the EONIA on repo rates is also reflected in the EONIA being the reference rate for floating rate repos.

\textsuperscript{13}The repo market is also more important for the transmission of monetary policy than the unsecured market for two other reasons: First, repo market frictions not only impact the funding conditions of banks, but also the borrowing conditions faced by other financial institutions and governments, as has been shown for the U.S. Treasury market by \textsuperscript{15}He et al. (2021). Given that governments are the largest debt issuers, this is another avenue through which the repo market affects monetary policy transmission. Second, the repo market in the euro area plays an important role for the redistribution of reserves (\textit{Bank for International Settlements, 2017}, p.16) which is also an important step in the process of monetary policy implementation. Banks do indeed trade in both the secured and the unsecured markets, actively linking the two segments (\textit{Di Filippo et al., 2021}). This linkage can be impacted by opportunity cost of collateral (\textit{Piquard and Salakhova, 2019}) or constrained arbitrage (\textit{Nyborg, 2019}).

\textsuperscript{14}A special repo is sometimes also referred to as a ‘specific’ repo in the U.S. market.

\textsuperscript{15}In a special repo, the lender accepts a lower interest rate than in a GC repo since a particular asset is specified as collateral; GC repo rates provide the upper bound for special repo rates.

\textsuperscript{16}Our setting provides several benefits including anonymity and central clearing removing frictions such as bargaining power, counterparty credit risk, and heterogeneous haircuts. Furthermore, the bilateral, over the counter (OTC) repo segment is very small and does not allow for a clear differentiation between general and special collateral repos.
The figure shows the development of the average volume-weighted repo rates for eligible and noneligible German assets as well as the GC rate relative to the development of the ECB’s deposit facility rate.

**Figure 2: Repo rate development for Germany**

for QE eligible and noneligible assets (illustratively for Germany) relative to the development of the ECB’s deposit facility rate. We observe two important developments: First, the GC rate has fallen below the ECB’s rate on the deposit facility at the height of the European sovereign debt crisis in 2012 and during the recent period of unconventional monetary policy. Second, during the QE period repo rates secured by assets eligible for QE have fallen below those for noneligible assets. Each observation points to a different feature of the central bank framework that we analyze. The first observation speaks to the importance of access to central bank facilities as it indicates that depositing funds at the deposit facility is attractive, in particular when the GC rate is below the deposit rate. The second observation highlights the role of asset scarcity induced by QE programs. Market participants are willing to accept a lower interest rate to lend cash against eligible than noneligible assets.\(^{17}\)

\(^{17}\)The spread between eligible and noneligible rates has been present since the introduction of QE and peaked at the end of 2017 when the ECB’s Securities Lending Programme was introduced (Brand et al. 2019), while specialness and asset scarcity in general also occurred before QE.
2.1 ECB access

The ECB operates two standing facilities that allow banks to deposit or access liquidity on an overnight basis: The deposit facility allows for overnight deposits, while the marginal lending facility provides overnight central bank liquidity. Access to the ECB’s facilities is, however, limited to eligible counterparties, most importantly to those banks that are subject to the Eurosystem’s minimum reserve requirements. The minimum reserve system applies to banks and credit institutions established in the euro area. Whether a bank is formed in- or outside of the euro area is unrelated to monetary policy and the repo market, and thus a source of exogenous variation. For our analysis, we exploit these eligibility criteria for access to the deposit facility. In particular, we consider the restriction that only euro area banks can access the deposit facility in order to classify lenders in a repo transaction into access and nonaccess banks.

The segmentation between access and nonaccess banks implies that access banks can safely invest liquidity in the repo market or place it at the deposit facility, whereas nonaccess banks can only rely on the former. This impacts the banks’ decision problems and their supply of repo lending. We provide a theoretical discussion of these mechanisms in section A.2 in the Appendix.

Depositing money at the deposit facility historically offered a smaller

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18 Additional criteria, for example on financial soundness, allow the ECB to suspend eligibility for institutions under certain circumstances. The full set of eligibility criteria can be found in EU Guideline 2015/510 of the European Central Bank on the implementation of the Eurosystem monetary policy framework available at https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:3201400060.19 The regulatory framework plays a negligible role in explaining our main findings for at least three reasons: First, access and nonaccess banks in our sample are similarly regulated. Nonaccess banks also need to fulfill Basel regulations in their home countries. Second, the new Basel (liquidity and capital) regulation considers all assets under inspection to be of the highest quality (Level 1 assets) from the perspective of the Liquidity Coverage Ratio (LCR) and liquidity regulation (Bank for International Settlements 2017). For example, we depict results which only consider repo transactions collateralized by German government bonds (which are safe and liquid). Furthermore, all maturities under inspection are shorter than the thirty-day LCR cut-off time. Third, the Basel III leverage ratio does not impact the lender in a repo transaction since reverse repos do not enter the Basel III leverage ratio calculation. This is because the lender is not exposed to the risk of the collateral (Ranaldo et al. 2021). Our classification of access and nonaccess banks refers to the lending counterparty in the repo trade, the effect of segmentation between access and nonaccess banks is therefore not driven by the leverage ratio regulation. The introduction of the leverage ratio lead to window-dressing effects on repo rates, but those were mainly caused by the borrowing counterparties.

20 Banks could also invest in government bonds directly as opposed to investing liquidity in the (reverse) repo market or when having access – placing funds at the deposit facility. However, direct government bond investments have several drawbacks and do not provide the same low-risk and liquid store of value as repos (Bank for International Settlements 2017). First, investing in government bonds exposes banks to a larger
return than other overnight lending or investment options since central bank reserves are considered the safest and most liquid asset. However, since 2015, repo rates in almost the entire European repo market have fallen below the rate on the deposit facility. This implies that storing funds at the deposit facility has become a more attractive option for those banks that have access to it.

(a) General collateral trading volumes
(b) Spread between average GC lending rates

Figure 3a depicts the total trading volume in the German GC market for trades involving a lender with and without access to the ECB facilities. Figure 3b depicts the spread between the average GC rate received by access and nonaccess lenders (nonaccess banks’ average rate minus access banks’ average rate). Grey shaded areas denote time periods in which the average GC rate was below the deposit rate.

Figure 3: General collateral repo market

Figure 3a shows the development of the total German GC trading volume for access and nonaccess banks while Figure 3b depicts the spread between the average GC rate received by access and nonaccess lenders. In the two periods during which GC rates fell below the rate on the deposit facility (i.e., in 2012 and since 2015), we observe a drop in GC trading volume. This drop is accompanied by an increase in the volume of funds deposited at the ECB’s deposit facility (see Figure A.3.1 in the Appendix). For example, since 2015, we observe a drop in GC trading volume to about a third of its original size. This reduction was mainly driven by banks that had access to the ECB’s deposit facility. Correspondingly, the share of lending volume by access banks dropped by around 15 percentage points (see Section A.4 in set of risks (e.g., market risks or duration risk / interest rate risk). Second, bond trades involve comparatively large transactions cost, in particular when bonds are purchased and sold on a daily basis to manage liquidity. Third, bond and repo markets differ in terms of their market structure. For example, bond trades are OTC and banks do not benefit from netting and central clearing.
the Appendix). To our knowledge, this is a new stylized fact which suggests a first form of segmentation between access and nonaccess banks induced by the central bank framework. Access banks increasingly deposit funds at the deposit facility when repo rates fall below the rate on the deposit facility, while nonaccess banks continue to lend in the GC market obtaining a (safe) deposit of liquidity. Access banks continue to have a motive for lending in the repo market despite the low rates due to the collateral received, an aspect that we discuss in more detail in section A.4 in the appendix. The excessive usage of the deposit facility by access banks raises concerns about discouraging interbank trading which inhibits price determination (Keister et al., 2008). This is in line with our idea of access banks being less responsive to changes in monetary policy.

The importance of the access to the central bank’s facilities is stressed in the literature. The deposit rate as the rate of remuneration for reserves is a general and important feature of financial intermediaries’ decision problems that is incorporated into macro-financial models (Cúrdia and Woodford, 2011; Bech and Monnet, 2016; Williamson, 2019). In these models, a single deposit rate applies uniformly to all market participants. However, different values of the rate would entail different equilibria in line with the mechanism that we discuss. Segmentation induced by different access levels to central bank facilities is also supported empirically. For instance, Bech and Klee (2011) argue that the level of the effective federal funds rate was pushed downward by government agencies that could not receive interest on reserves. Kraenzlin and Nellen (2015) find that banks without access to central bank facilities pay more interest in the unsecured money market to borrow liquidity.

2.2 Asset eligibility

The ECB followed other major central banks in 2015 by announcing its intention to conduct large-scale asset purchases. Since the beginning of these programs, cumulative net

\(^{2}\)Bech and Klee (2011) differ from our study in key aspects. First, they evaluate different interest rate levels, not the continuous pass-through of a monetary policy rate. Second, their analysis is confined to the unsecured market, while we look at the secured funding market. Finally, the financial friction to which their effects are attributed is bargaining power, a friction that does not play a role in a centrally-cleared setting like ours.
purchases amounted to more than 2.5 trillion euro. The Public Sector Purchase Program is the largest of the programs implemented in the Eurosystem, it focuses on the purchase of government bonds.\footnote{Under the umbrella of the PSPP, the ECB buys nominal and inflation-linked government bonds as well as securities issued by recognized agencies, regional and local governments, international organizations, and multilateral development banks located in the euro area. Overall, around 90\% of purchases correspond to government bonds.} The sheer size of these purchases has contributed to scarcity effects for government bonds, which are an important category of safe assets and serve as collateral in repo transactions. QE programs in general aim to influence longer-term rates in an environment where short-term rates are at the zero lower bound (by affecting term premia, see Eser et al., 2019). An impact of QE-induced asset scarcity on short-term rates is thus an unintended side effect that can increase rate dispersion and thereby limits control over the pass-through. The effect of asset purchases on bond scarcity comes on top of tighter regulation of financial institutions under the new Basel framework (e.g., the introduction of the Leverage Ratio rules). The ECB has therefore constituted implementation provisions to limit market impacts and distortions. These provisions specify the conditions under which the ECB (via local central banks) is allowed to purchase government bonds: they contain (i) a maturity restriction that specifies the minimum and maximum remaining maturity of a security, (ii) a yield restriction that states that the yield of a security needs to be above the ECB’s deposit facility rate, and (iii) it only allows for the purchase of bonds denominated in euro.\footnote{Over time, the ECB has adjusted and modified the initial implementation provisions. For example, the yield restriction ceased to exist at the end of 2017.} The implementation provisions for asset purchases provide a source of exogenous variation as to which securities meet the respective criteria.

In our analysis, we exploit the implementation provisions to classify collateral in a repo transaction into \textit{eligible} and \textit{noneligible} depending on the provisions that were valid at a specific point in time. We further apply the initial implementation provisions retrospectively to compare time trends between (hypothetically) \textit{eligible} and \textit{noneligible} assets, which creates a difference-in-difference estimation setting. Observing similar reactions of both types of assets before QE would imply common trends and would allow us to interpret the QE impact as causal.
Figure 4a depicts the total trading volume in the special collateral market for trades involving eligible and noneligible collateral. Figure 4b depicts the spread between the average repo rate on noneligible and eligible securities (average rate for noneligible collateral minus average rate for eligible collateral).

**Figure 4:** Special collateral repo market

Figure 4a shows the development of the total trading volume in special collateral for eligible and noneligible securities while Figure 4b depicts the spread between the average repo rate on noneligible and eligible securities. During the recent period of unconventional monetary policy, repo rates for eligible assets have fallen below those of noneligible assets. The spread between noneligible and eligible assets was always positive during the QE period and has increased further after the expansion and extension of the program. A second, new stylized fact emerges as we observe an increase in special collateral trading volume since the start of QE, an increase that is predominantly driven by eligible assets\(^\text{24}\). This is in line with our idea that repos secured by assets that are eligible for QE tend to become scarcer, their specialness premium increases, and they become predominantly driven by collateral demand. We provide a theoretical discussion of these mechanisms in section A.2 in the appendix.

The interplay of central bank asset purchases, financial intermediation, and collateral has been featured prominently in the theoretical literature. Gertler and Karadi (2013) show that if limits to arbitrage exist in the banking sector, central bank purchases of securities

\(^{24}\)Since the implementation provisions have changed during the course of the program, the increase in the trading share of eligible assets is partly driven by an easing of the restrictions. The decline in eligible trading volume towards the end of 2017 was driven by German collateral trading at a yield below the ECB’s deposit facility. The ECB therefore decided in January 2017 to void the yield restriction.
cause yields to fall. Araújo et al. (2015) stress that the direction of the impact of asset purchases depends on the way collateral constraints are impacted. Piquard and Salakhova (2019) highlight how monetary policy affects unsecured and secured markets in a different way once the central bank purchases marketable collateral. Their mechanism is motivated by an increase in the opportunity cost of pledging collateral. Divergent QE effects on financial markets are also supported empirically. For instance, Arrata, Nguyen, Rahmouni-Rousseau, and Vari (2020) and Corradin and Maddaloni (2020) show that asset purchases lowered special repo rates. Schlepper, Riordan, Hofer, and Schrimpf (2017) show that QE increased prices and lowered liquidity in purchased German bonds. Kojien, Koulicher, Nguyen, and Yogo (2017) show that in response to the ECB’s purchasing programs, foreign investors sold most of their QE eligible bond holdings to domestic investors pointing to a strong home bias in eligible securities.

2.3 Data

We employ high-frequency data for the European repo market for the time period from 2010 to 2020. Our data includes all electronically traded repo transactions in euro on the three main trading platforms (i.e., BrokerTec, Eurex, and MTS) and covers more than 70% of the entire repo market universe. For each transaction, we observe the trade date, the term, the trade volume, the rate, the collateral identified by a unique ISIN (for special repos) or basket (for GC repos), the lender, the borrower, the aggressor type and the trading platform. We focus on the term types Overnight (ON), Tomorrow-Next (TN), and Spot-Next (SN), with the purchase date being tonight, tomorrow, or the day after tomorrow, respectively, and the repurchase date one day thereafter. These three term types make up 97% of the entire repo market trading volume. Trading in the GC market predominantly takes place in the ON and TN market segments, whereas trading in the special repo market segment predominantly takes place in the TN and SN market segments.

We exclude a very small fraction of repo contracts and trading days to ensure the robust-
ness and general validity of our results. First, we exclude holidays as well as year end trading days. We further provide robustness checks excluding all quarter end and end of ECB maintenance period trading days, as well as the corresponding weeks. Second, we exclude special repos secured by corporate securities. Third, we exclude repos with floating rates, repos with open term type, bilaterally pre-arranged repos as well as repos that are not cleared via a central counterparty (CCP). Finally, we exclude repos that are traded infrequently.\footnote{To be included in our analysis, a repo needs to be traded at least 100 times. In addition, between the issuance and maturity of the underlying collateral, a repo needs to be traded at least once every two weeks 95\% of the time. Our results are robust to different specifications.} We perform our analyses for three different groups of countries: (i) Germany, (ii) core European countries, and (iii) all European countries.\footnote{Core European countries include Austria, Belgium, Finland, France, Germany and the Netherlands, all European countries include in addition EU, Ireland, Italy, Portugal and Spain.}

To identify banks, we follow the approach of Ranaldo et al.\citeyear{Ranaldo2019} as well as Di Filippo et al.\citeyear{Filippo2021} based on supervisory data. We then classify banks into access and nonaccess institutions depending on whether they need to fulfill the reserve requirements of the Eurosystem and have access to the deposit facility. Banks trading in the repo market are, for example, Deutsche Bank AG and Nordea Bank Danmark A/S. The former is a euro area bank with access to the deposit facility, while the latter is a foreign bank without access.\footnote{For our classification, we assume that local subsidiaries of global banking institutions operate independently in the short-run. Thus, euro area subsidiaries of foreign banking groups have access to the deposit facility while foreign subsidiaries of euro area banking groups do not have access to the deposit facility.}

Our data contains GC repo trades involving 98 different banks, of which 85 are access banks and 13 are nonaccess banks.\footnote{The number of nonaccess banks is constant over the course of our sample, thereby mitigating endogeneity concerns of nonaccess banks switching their location to access the deposit facility.} We observe information on both the lending and borrowing bank for trades featuring 59\% of the entire trading volume; among those trades, 22\% are associated with a nonaccess bank. To ensure that the two groups of access and nonaccess banks are comparable, we analyze their important characteristics. For instance, at the end of our sample period, access banks had, on average, assets worth 290 million euro compared to 240 million euro for nonaccess banks, the leverage ratios were about 17 for both types of banks.

Moreover, we classify assets as eligible and noneligible for QE according to the PSPP’s
implementation provisions. We also apply the initial implementation provisions retrospec-
tively. Our data set contains special repo trades involving more than 2,000 different collateral
assets (ISINs). Seventy-six percent of our sample involves repo trades collateralized by (hy-
pothetically) eligible assets, 24% collateralized by noneligible assets.

3. Empirical results

We empirically evaluate the immediate reaction of repo rates to monetary policy changes
and thus consider the continuous monetary policy pass-through in the first step of the mon-
etary policy transmission pipeline.

3.1 Access/nonaccess banks

We first want to understand whether the access restrictions to central bank facilities lead
to a monetary policy disconnect. In particular, we ask whether access and nonaccess banks
behave differently in the monetary policy transmission process. Access banks always have
the possibility to deposit funds at the deposit facility; our first testing hypothesis is therefore
that access banks react less strongly to changes in the monetary policy target rate. Given
that “in an idealized money market, any change in the main monetary policy rate should pass
through perfectly to all money market rates” (Corradin et al., 2020, p.13), this would imply
less control of the monetary policy transmission for central banks and indicate pass-through
inefficiencies.

We provide a first graphical intuition of the analysis in Figure 5 that illustrates the lower
sensitivity of access banks to changes in the monetary policy target rate in the form of impulse
response functions. We compute the impulse response function for trades involving access
and nonaccess banks separately for periods during which the GC rate is above the deposit
rate (left panel) and below the deposit rate (right panel). The coefficients are derived from a
time series regression of current repo rate changes on the concurrent and the ten preceding
monetary policy rate changes.\(^{30}\)

\(^{30}\) We control for basket-month-term fixed effects and include heteroscedasticity-robust standard errors.
The figure depicts the impulse response function of repo rates to changes in the monetary policy target rate for trades involving access and nonaccess banks in the period when the average GC rate is above (left panel) and below the rate on the deposit facility (right panel). The coefficients are derived from a time series regression of current repo rate changes on the concurrent and the ten preceding monetary policy rate changes controlling for basket-month-term fixed effects. The regression includes heteroscedasticity-robust standard errors. Data include GC repo transactions for Germany for the term types ON and TN for the time-period 2010–2018.

**Figure 5:** Impulse response for German trades involving access/nonaccess banks
The left panel highlights that access and nonaccess banks react similarly during periods when the GC rate is above the deposit rate, with the point estimate for access banks being slightly smaller. Even if the deposit facility provides a smaller remuneration than a repo trade, the storage of liquidity at the facility is convenient for access banks, thus explaining their overall lower sensitivity to monetary policy changes. However, once the GC rate is below the rate on the deposit facility, the sensitivity of access banks is completely muted, while nonaccess banks exhibit an even higher sensitivity. Nonaccess banks do not have the outside option of storing funds at the deposit facility, thus, they are still active in the repo market. However, since they are accepting a lower rate to invest funds, they tend to be more sensitive to changes in the policy rate. The graphical results point towards a less effective monetary policy transmission once GC rates fall below the rate on the deposit facility associated with access banks reacting less to changes in the monetary policy target rate and a larger dispersion in repo rates of access and nonaccess banks.

For the empirical analysis, we formalize the graphical intuition in a set of panel regressions. Our main regression equations read as follows:

\begin{align*}
\Delta r^{GC}_{t,i,l} &= \beta_1 \cdot \Delta PolRate_t + \beta_2 \cdot D^{Dep}_{t,n} + \beta_3 \cdot \Delta PolRate_t \cdot D^{Dep}_{t,n} + \beta_4 \cdot \Delta r^{GC}_{t-1,i,l} + \epsilon_t \\
\Delta r^{GC}_{t,i,l} &= \beta_1 \cdot \Delta PolRate_t + \beta_2 \cdot D^{Access}_{t,l} + \beta_3 \cdot \Delta PolRate_t \cdot D^{Access}_{t,l} + \beta_4 \cdot \Delta r^{GC}_{t-1,i,l} + \epsilon_t \\
\Delta r^{GC}_{t,i,l} &= \beta_1 \cdot \Delta PolRate_t + \beta_2 \cdot D^{Dep}_{t,n} + \beta_3 \cdot D^{Access}_{t,l} + \beta_4 \cdot \Delta PolRate_t \cdot D^{Dep}_{t,n} + \beta_5 \cdot \Delta PolRate_t \cdot D^{Access}_{t,l} + \beta_6 \cdot \Delta PolRate_t \cdot D^{Dep}_{t,n} \cdot D^{Access}_{t,l} + \beta_7 \cdot \Delta r^{GC}_{t-1,i,l} + \epsilon_t,
\end{align*}

where $\Delta r^{GC}_{t,i,l}$ denotes the log-change in GC repo rates of basket $i$ and lender type (access / nonaccess) $l$ at time $t$ and $\Delta PolRate_t$ denotes the log-change in the EONIA. Moreover, we employ two dummy variables: $D^{Dep}_{t,n}$, which is equal to one if country $n$’s average GC rate is below the deposit facility rate, and $D^{Access}_{t,l}$, which is equal to one if the lender $l$ has access to

Trading in the more liquidity-driven GC repo market is concentrated in the ON and TN term types; we therefore include those two term types in the regression.
the deposit facility. Similar to the impulse response functions, we add basket-month-term fixed effects and employ heteroscedasticity-robust standard errors. And since trading in the more liquidity-driven GC repo market is concentrated in the ON and TN term types, we show our main results as a pooled regression of both term types in Table 1. We report our results for (i) Germany in columns 1–3, (ii) core European countries in columns 4–6, and (iii) all countries in columns 7–9.

As a first step, we consider repo transactions collateralized by German government securities. Since German collateral is considered to be safe and liquid, this limits concerns about cross-country differences in sovereign risk and liquidity. Regression (1) relates changes in GC rates to changes in the monetary policy target rate, depending on whether the GC rate is above or below the rate on the deposit facility. The results highlight that GC rates react strongly: A one-percentage-point decrease in the target rate is accompanied by a decrease in GC rates of about 54 basis points. The effect is smaller at 36 basis points when the GC rate is below the rate on the deposit facility. In Regression (2), we analyze the different reactions of access and nonaccess banks. We find that GC trades involving a lender with access to the deposit facility react less strongly. A decrease in the target rate by one percentage point relates to a decrease in GC rates involving access banks of 45 basis points as compared to 72 basis points for nonaccess banks. Considering our main Regression (3), which includes both dummy variables, we observe a combined effect: GC rates involving lenders with access tend to react less, their reaction is particularly weak when GC rates are below the rate on the deposit facility. In this setting, the effect of changes in the monetary policy target rate on GC rates is 68 basis points for nonaccess banks as compared to 50 basis points for access banks for when GC rates are above the deposit rate. Once GC rates are below the rate on the deposit facility, the effect increases to 94 basis points for nonaccess banks while it decreases to 4 basis points for access banks. This indicates that lenders with access to the deposit facility do not react to changes in the target rate once GC rates are below the rate on the

The denominations are: $\Delta r_{GC}^{t,i,l}$ is the log change in the volume weighted average daily repo rate per basket and lender type in percentage points. Correspondingly, $\Delta PotRate_t$ refers to the log change in the EONIA denoted in percentage points.
Table 1: ECB access

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>Core</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>( \Delta repo^{GC} ) ON/TN</td>
<td>( \Delta repo^{GC} )</td>
<td>( \Delta repo^{GC} )</td>
<td>( \Delta repo^{GC} )</td>
</tr>
<tr>
<td>( \Delta PolRate )</td>
<td>( 0.539^{***} )</td>
<td>( 0.717^{***} )</td>
<td>( 0.675^{***} )</td>
</tr>
<tr>
<td></td>
<td>(15.699)</td>
<td>(10.745)</td>
<td>(8.781)</td>
</tr>
<tr>
<td>( D^{Dep} )</td>
<td>( -0.046^{**} )</td>
<td>( -0.047^{**} )</td>
<td>( -0.031^{***} )</td>
</tr>
<tr>
<td></td>
<td>(−2.265)</td>
<td>(−2.338)</td>
<td>(−2.851)</td>
</tr>
<tr>
<td>( \Delta PolRate \cdot D^{Dep} )</td>
<td>( -0.176^{**} )</td>
<td>( 0.265^{**} )</td>
<td>( -0.061 )</td>
</tr>
<tr>
<td></td>
<td>(−2.216)</td>
<td>(2.082)</td>
<td>(−1.141)</td>
</tr>
<tr>
<td>( D^{Access} )</td>
<td>( -0.001 )</td>
<td>( -0.000 )</td>
<td>( -0.005 )</td>
</tr>
<tr>
<td></td>
<td>(−0.071)</td>
<td>(−0.035)</td>
<td>(−0.019)</td>
</tr>
<tr>
<td>( \Delta PolRate \cdot D^{Access} )</td>
<td>( -0.264^{***} )</td>
<td>( -0.177^{**} )</td>
<td>( -0.284^{***} )</td>
</tr>
<tr>
<td></td>
<td>(−3.549)</td>
<td>(−2.100)</td>
<td>(−6.242)</td>
</tr>
<tr>
<td>( \Delta PolRate \cdot D^{Access} \cdot D^{Dep} )</td>
<td>( -0.719^{***} )</td>
<td>( -0.574^{***} )</td>
<td>( -0.616^{***} )</td>
</tr>
<tr>
<td></td>
<td>(−4.570)</td>
<td>(−5.860)</td>
<td>(−5.860)</td>
</tr>
<tr>
<td>( \Delta repo^{GC} ) lagged</td>
<td>( -0.332^{***} )</td>
<td>( -0.332^{***} )</td>
<td>( -0.372^{***} )</td>
</tr>
<tr>
<td></td>
<td>(−14.230)</td>
<td>(−14.147)</td>
<td>(−30.233)</td>
</tr>
</tbody>
</table>

The table reports the regression results examining the impact of access to the ECB’s deposit facility on the pass-through of the monetary policy target rate into GC repo rates. The dependent variable is the change in the GC rate \( \Delta repo^{GC} \). \( \Delta PolRate \) denotes the change in the policy rate. \( D^{Dep} \) equals 1 if a country’s average GC rate is below the deposit facility rate. \( D^{Access} \) equals 1 if a lending bank has access to the deposit facility. \( \Delta PolRate \cdot D^{Dep} \) equals 1 if a country’s average GC rate is below the deposit facility rate and the lending bank has access to the deposit facility. ***, **, * and t-statistics are in parentheses. All regressions include basket-month-term fixed effects and heteroscedasticity-robust standard errors. Data include GC repo transactions for Germany, core European countries and all European countries pooled across the term types ON and TN for the time-period 2010-2018.
deposit facility, while lenders without access are very sensitive to it.\footnote{We observe a significant negative autocorrelation in repo rates, which is expected under mean reversion.}

We perform a number of additional robustness checks to confirm our main results. First, columns 4–9 expand our analysis by looking at larger samples consisting of core European countries as well as all European countries. Overall, the results remain statistically and economically consistent. This indicates that the impact of having access to central bank facilities is not only present in the German “safe haven” market but across European countries as well. Second, we report consistent results for each term type and regional classification. Third, the results are also robust for different standard error and fixed effect specifications. Fourth, we repeat our analysis in a sample without quarter end and end of ECB maintenance period days and weeks. Our results on the monetary policy pass-through are robust to removing those days that are characterized by higher idiosyncratic movements and spikes. And finally, we replicate our results for the sub-period until 2016 to account for the lower volatility in the EONIA in recent years. All those robustness checks are reported in the Online Appendix.

To gain additional insight into our mechanism and the role of the deposit facility rate reflecting the opportunity cost of engaging in repo trade within access banks’ decision problem, we extend our analysis by looking at the distance between the GC rate and the rate on the deposit facility. Our idea is that the lower sensitivity of access banks to changes in monetary policy is stronger for periods when the opportunity cost of engaging in a repo trade are higher, i.e., when the GC rate is closer to or falls below the DFR. We therefore introduce a new, continuous variable “DFR Distance” measuring the difference between the deposit facility rate and the GC rate with positive values indicating that GC rates are below the deposit facility rate.

Table 2 reports the regression results focusing on the distance of repo rates to the deposit facility rate. We show two regression specifications: (i) by employing our new DFR Distance variable, and (ii) by employing three buckets with $DFR1$ indicating time periods when the GC rate is between 25-50 basis points above the deposit facility rate, $DFR2$ indicating
Table 2: ECB access: Distance to deposit facility rate

<table>
<thead>
<tr>
<th></th>
<th>Germany (1)</th>
<th>Core (2)</th>
<th>All (3)</th>
<th>Germany (4)</th>
<th>Core (5)</th>
<th>All (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta repo^{GC} )</td>
<td>ON/TN b/t</td>
<td>ON/TN b/t</td>
<td>ON/TN b/t</td>
<td>ON/TN b/t</td>
<td>ON/TN b/t</td>
<td>ON/TN b/t</td>
</tr>
<tr>
<td>( \Delta PolRate )</td>
<td>0.716***</td>
<td>0.716***</td>
<td>0.684***</td>
<td>0.684***</td>
<td>0.589***</td>
<td>0.589***</td>
</tr>
<tr>
<td>( \Delta PolRate \cdot D^{Access} )</td>
<td>-0.005</td>
<td>-0.004</td>
<td>-0.007</td>
<td>-0.007</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>( \Delta PolRate \cdot D^{Access} \cdot D^{DFR1} )</td>
<td>-0.386***</td>
<td>0.108</td>
<td>-0.411***</td>
<td>0.149**</td>
<td>-0.334***</td>
<td>0.172***</td>
</tr>
<tr>
<td>( \Delta PolRate \cdot D^{Access} \cdot D^{DFR2} )</td>
<td>(1.183)</td>
<td>(-8.421)</td>
<td>(2.575)</td>
<td>(-8.083)</td>
<td>(3.210)</td>
<td></td>
</tr>
<tr>
<td>( \Delta PolRate \cdot D^{Access} \cdot D^{DFR3} )</td>
<td>(-4.772)</td>
<td>(1.183)</td>
<td>(-8.421)</td>
<td>(2.575)</td>
<td>(-8.083)</td>
<td>(3.210)</td>
</tr>
<tr>
<td>( \Delta repo^{GC} ) lagged</td>
<td>-0.333***</td>
<td>-0.332***</td>
<td>-0.335***</td>
<td>-0.336***</td>
<td>-0.372***</td>
<td>-0.373***</td>
</tr>
<tr>
<td>( \Delta PolRate \cdot D^{Access} \cdot D^{DFR3} )</td>
<td>(-14.091)</td>
<td>(-14.127)</td>
<td>(-24.408)</td>
<td>(-24.478)</td>
<td>(-30.215)</td>
<td>(-30.261)</td>
</tr>
</tbody>
</table>

The table reports the regression results examining the impact of access to the ECB’s deposit facility on the pass-through of the monetary policy target rate into GC repo rates with a focus on the distance of repo rates to the deposit facility rate. The dependent variable is the change in the GC rate \( \Delta repo^{GC} \). \( \Delta PolRate \) denotes the change in the policy rate. \( D^{Access} \) equals 1 if a lending bank has access to the deposit facility. \( D^{DFR} \) refers to the difference between the deposit facility rate and a country’s average GC rate. \( D^{DFR1} \) indicates time periods when the GC rate is between 25-50 basis points above the deposit facility rate, \( D^{DFR2} \) indicates time periods when the GC rate is between 0-25 basis points above the deposit facility rate, and \( D^{DFR3} \) indicates time periods when the GC rate is below the deposit facility rate. ***, **, and * represent significance at a 1, 5, and 10% level, respectively; t-statistics are in parentheses. All regressions include basket-month-term fixed effects and heteroscedasticity-robust standard errors. Data include GC repo transactions for Germany, core European countries and all European countries pooled across the term types ON and TN for the time-period 2010–2018.
time periods when the GC rate is between 0-25 basis points above the deposit facility rate, and $DFR3$ indicating time periods when the GC rate is below the deposit facility rate. For all regressions, we replace our previous $D^{Dep}$ dummy with the newly introduced DFR Distance variable or the respective DFR Distance buckets, interacted with the log-change in the monetary policy rate $\Delta PolRate_t$. We report our results for (i) Germany in columns 1 and 2, (ii) core European countries in columns 3 and 4, and (iii) all countries in columns 5 and 6.

Our results highlight that the distance of GC repo rates to the deposit facility rate has a continuous impact on access banks. Regression (1) shows that the sensitivity of access banks to changes in the monetary policy rate decreases in the difference between the deposit facility rate and the GC rate. For example, if the difference between the deposit facility rate and the GC rate increases by 10 basis point, the sensitivity of access banks to changes in monetary policy reduces by 7 basis points. Regression (2) confirms that access banks already become less reactive to monetary policy changes when GC rates get close to the DFR, this effect is intensified once GC rates drop below the DFR when the reaction of access banks to changes in monetary policy is completely muted.

### 3.2 Introduction of ECB tiering as natural experiment

To provide further evidence of the causal impact of the convenience of the deposit facility for banks with access to it to their weaker reaction to changes in monetary policy, we consider the introduction of the ECB’s two-tier system for remunerating excess reserve holdings (“tiering”) in 2019 as a natural experiment. The two-tier system provides each access bank with an allowance to store excess reserves at the ECB without paying the negative deposit rate that would generally apply to them. For holdings above the allowance, the deposit facility rate continues to apply. The introduction of the tiering implies that the deposit facility becomes an even more attractive option for access banks to store liquidity, in particular for those access banks that still have unused allowances. Indeed, Fuster et al. (2021) found that an increase in exemption allowances in Switzerland induced banks to deposit more funds at the
Table 3: ECB access: Introduction of ECB tiering system

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>Core</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Δrepo&lt;sup&gt;GC&lt;/sup&gt;</td>
<td>ON/TN</td>
<td>ON/TN</td>
<td>ON/TN</td>
</tr>
<tr>
<td></td>
<td>b/t</td>
<td>b/t</td>
<td>b/t</td>
</tr>
<tr>
<td>∆PolRate</td>
<td>0.887***</td>
<td>0.752***</td>
<td>0.774***</td>
</tr>
<tr>
<td></td>
<td>(17.552)</td>
<td>(13.238)</td>
<td>(17.169)</td>
</tr>
<tr>
<td>DTiering</td>
<td>-0.017*</td>
<td>-0.022***</td>
<td>-0.043***</td>
</tr>
<tr>
<td></td>
<td>(-1.961)</td>
<td>(-3.406)</td>
<td>(-4.550)</td>
</tr>
<tr>
<td>ΔPolRate ⋅ DTiering</td>
<td>0.086</td>
<td>-0.034</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.629)</td>
<td>(-0.268)</td>
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</tr>
<tr>
<td>DAccess</td>
<td>0.002</td>
<td>-0.003</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.344)</td>
<td>(-1.023)</td>
<td>(0.053)</td>
</tr>
<tr>
<td>ΔPolRate ⋅ DAccess</td>
<td>-0.076</td>
<td>0.048</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>(-0.672)</td>
<td>(0.544)</td>
<td>(0.509)</td>
</tr>
<tr>
<td>ΔPolRate ⋅ DAccess ⋅ DTiering</td>
<td>-0.350</td>
<td>-0.566**</td>
<td>-0.758**</td>
</tr>
<tr>
<td></td>
<td>(-1.181)</td>
<td>(-2.451)</td>
<td>(-2.294)</td>
</tr>
<tr>
<td>Δrepo&lt;sup&gt;GC&lt;/sup&gt; lagged</td>
<td>-0.191***</td>
<td>-0.200***</td>
<td>-0.564***</td>
</tr>
<tr>
<td></td>
<td>(-3.826)</td>
<td>(-6.184)</td>
<td>(-4.633)</td>
</tr>
</tbody>
</table>

| N  | 516 | 1,657 | 2,811 |
| R² | 0.470 | 0.357 | 0.334 |

The table reports the regression results examining the impact of the ECB’s introduction of the tiering program on the pass-through of the monetary policy target rate into GC repo rates. The dependent variable is the change in the GC rate Δrepo<sup>GC</sup>. ΔPolRate denotes the change in the policy rate. DTiering equals 1 during the period the tiering was in place beginning on October 30th, 2019. DAccess equals 1 if a lending bank has access to the deposit facility. ***, **, and * represent significance at a 1, 5, and 10% level, respectively; t-statistics are in parentheses. All regressions include basket, month, and term fixed effects and heteroscedasticity-robust standard errors. Data include GC repo transactions for Germany, core European countries and all European countries pooled across the term types ON and TN for the time-period of the two ECB maintenance periods preceding the ECB Tiering introduction as well as the two ECB maintenance periods thereafter (August 2019 to January 2020).
deposit facility and restrict their lending activities. Consequently, we expect the reactivity of access banks to monetary policy to weaken after the tiering exemptions were introduced.

To isolate the impact of the tiering on access banks’ sensitivity to changes in monetary policy, we consider an adapted version of our empirical analysis for the time period around the introduction of the two-tier system covering the two ECB maintenance periods before and after the introduction.\textsuperscript{33} For this, we introduce the dummy variable $D_{\text{Tiering}}$, which is equal to one after the introduction of the tiering system on October 30th, 2019. For all regressions, we replace our previous $D_{\text{Dep}}$ dummy with the newly introduced $D_{\text{Tiering}}$ dummy, interacted with changes in the policy rate.

The results as displayed in Table 3 show that access banks are less responsive to monetary policy changes after the introduction of the tiering. This effect is significant for core and all European countries in line with the idea that banks in those peripheral countries have benefited most from the introduction of the tiering and thus became less reactive to monetary policy. The two-tier system has a strong impact on banks that still have room in their allowance, which is more common in the periphery, for example in Italy (Coeuré, 2018). Due to the home bias observed among European financial institutions (Koijen et al., 2017), this implies that the pass-through becomes particularly inhibited in GC baskets associated with periphery countries.

### 3.3 Eligible/noneligible assets

We also want to understand whether the eligibility criteria for QE programs impede the monetary policy transmission and lead to a monetary policy disconnect. Eligible collateral is scarce and in high demand; our second testing hypothesis is therefore that repo rates secured by assets eligible for QE are less aligned to the monetary policy target rate. Similar to the previous analysis, a lower sensitivity implies more difficulties in controlling the monetary policy transmission from the unsecured to the secured funding market. Again, we perform a set of panel analyses. Our main regression equations read as follows:

\textsuperscript{33}This natural experiment is an out-of-sample analysis, hence the introduction of the tiering did not impact our main results.
\[
\Delta r_{t,i,l}^{Special} = \beta_1 \cdot \Delta PolRate_t + \beta_2 \cdot D_t^{QE} + \beta_3 \cdot \Delta PolRate_t \cdot D_t^{QE} + \beta_4 \cdot \Delta r_{t-1,i,l}^{Special} + \epsilon_t 
\]  
(4)

\[
\Delta r_{t,i,l}^{Special} = \beta_1 \cdot \Delta PolRate_t + \beta_2 \cdot D_{t,i}^{Eligible} + \beta_3 \cdot \Delta PolRate_t \cdot D_{t,i}^{Eligible} + \beta_4 \cdot \Delta PolRate_t \cdot D_t^{QE} + \beta_5 \cdot \Delta r_{t-1,i,l}^{Special} + \epsilon_t 
\]  
(5)

\[
\Delta r_{t,i,l}^{Special} = \beta_1 \cdot \Delta PolRate_t + \beta_2 \cdot D_t^{QE} + \beta_3 \cdot D_{t,i}^{Eligible} + \beta_4 \cdot \Delta PolRate_t \cdot D_t^{QE} + \beta_5 \cdot \Delta PolRate_t \cdot D_{t,i}^{Eligible} + \beta_6 \cdot \Delta PolRate_t \cdot D_{t,i}^{Eligible} + \beta_7 \cdot \Delta r_{t-1,i,l}^{Special} + \epsilon_t 
\]  
(6)

where \( \Delta r_{t,i,l}^{Special} \) denotes the log-change in special repo rates and \( \Delta PolRate_t \) denotes the log-change in the EONIA. Moreover, we employ two dummy variables: \( D_{t,i}^{Eligible} \), which is equal to one if security \( i \) is (hypothetically) eligible for purchase under the PSPP, and \( D_t^{QE} \), which is equal to one after the introduction of the PSPP in March 2015. Additionally, we add ISIN-month-term fixed effects and heteroscedasticity-robust standard errors. Trading in the special repo market is concentrated in the TN and SN term types; we therefore show our main results as a pooled regression in Table 4. We report our results for (i) Germany in columns 1–3, (ii) core European countries in columns 4–6, and (iii) all countries in columns 7–9.

Regression (1) relates changes in special repo rates to changes in the monetary policy target rate in the period prior to and after the introduction of the QE program. A more accommodative monetary policy that results in a decrease in the target rate by one percentage point translates into a decrease of around 11 basis points in special repo rates in the period prior to the PSPP. During the current period of unconventional monetary policy, the effect has been muted. Although well expected, a new stylized fact emerges as special rates react less strongly to changes in the monetary policy target rate than more liquidity-driven GC rates. Still, also a special repo trade involves a funding motive and reacts to changes in funding conditions. In Regression (2), we consider the impact of market segmentation along the lines of asset eligibility for QE in a difference-in-difference setting. The dummy variable

\[34 \] The fixed effects capture all bond-specific properties that are constant within a month, for example, issue size or on-the-run status.
Table 4: Asset eligibility

<table>
<thead>
<tr>
<th></th>
<th>Germany Core All</th>
<th>Germany Core All</th>
<th>Germany Core All</th>
<th>Germany Core All</th>
<th>Germany Core All</th>
<th>Germany Core All</th>
<th>Germany Core All</th>
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<th>Germany Core All</th>
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<td></td>
<td>(1)</td>
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<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
<td>(9)</td>
</tr>
<tr>
<td>$\Delta PolRate$</td>
<td>0.106***</td>
<td>0.098***</td>
<td>0.109***</td>
<td>0.095***</td>
<td>0.103***</td>
<td>0.099***</td>
<td>0.094***</td>
<td>0.101***</td>
<td></td>
</tr>
<tr>
<td>$DQE$</td>
<td>-0.016</td>
<td>-0.016</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.020**</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.020**</td>
</tr>
<tr>
<td></td>
<td>(-1.448)</td>
<td>(-1.420)</td>
<td>(-1.176)</td>
<td>(-1.157)</td>
<td>(-2.001)</td>
<td>(-1.996)</td>
<td>(-1.157)</td>
<td>(-2.001)</td>
<td>(-1.996)</td>
</tr>
<tr>
<td>$\Delta PolRate$ $DQE$</td>
<td>-0.150***</td>
<td>-0.120***</td>
<td>-0.126***</td>
<td>-0.106***</td>
<td>-0.108***</td>
<td>-0.091***</td>
<td>-0.106***</td>
<td>-0.091***</td>
<td>-0.108***</td>
</tr>
<tr>
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<td>(-15.860)</td>
<td>(-8.160)</td>
<td>(-19.822)</td>
<td>(-9.820)</td>
<td>(-17.347)</td>
<td>(-8.349)</td>
<td>(-17.347)</td>
<td>(-8.349)</td>
<td></td>
</tr>
<tr>
<td>$DEligible$</td>
<td>0.004</td>
<td>0.004</td>
<td>0.003</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>(0.443)</td>
<td>(0.428)</td>
<td>(0.580)</td>
<td>(0.570)</td>
<td>(0.236)</td>
<td>(0.214)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta PolRate$ $DEligible$</td>
<td>0.006</td>
<td>-0.005</td>
<td>0.011</td>
<td>0.002</td>
<td>0.004</td>
<td>-0.004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.537)</td>
<td>(-0.462)</td>
<td>(1.622)</td>
<td>(0.290)</td>
<td>(0.564)</td>
<td>(-0.556)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$\Delta PolRate$ $DEligible$ $DQE$</td>
<td>-0.172***</td>
<td>-0.032***</td>
<td>-0.136***</td>
<td>-0.030**</td>
<td>-0.116***</td>
<td>-0.026*</td>
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<tr>
<td></td>
<td>(-14.030)</td>
<td>(-2.736)</td>
<td>(-17.421)</td>
<td>(-2.211)</td>
<td>(-15.232)</td>
<td>(-1.936)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta repo^{Special}$ lagged</td>
<td>-0.358***</td>
<td>-0.358***</td>
<td>-0.358***</td>
<td>-0.354***</td>
<td>-0.359***</td>
<td>-0.359***</td>
<td></td>
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<tr>
<td></td>
<td>(-69.830)</td>
<td>(-69.823)</td>
<td>(-103.753)</td>
<td>(-103.736)</td>
<td>(-119.675)</td>
<td>(-119.636)</td>
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The table reports the regression results examining the impact of asset eligibility for quantitative easing programs on the pass-through of the monetary policy target rate into special repo rates. The dependent variable is the change in the special rate $\Delta repo^{Special}$. $\Delta PolRate$ denotes the change in the policy rate. $DQE$ equals 1 during the PSPP. $DEligible$ equals 1 if a security is (hypothetically) eligible for purchase under the PSPP. ***, **, and * represent significance at a 1, 5, and 10% level, respectively; t-statistics are in parentheses. All regressions include ISIN-month-term fixed effects and heteroscedasticity-robust standard errors. Data include special repo transactions for Germany, core European countries and all European countries pooled across the term types ON and TN for the time-period 2010–2018.
$D_{t,i}^{\text{Eligible}}$ measures whether the underlying collateral asset fulfills the eligibility criteria since the start of the program and whether it had (hypothetically) fulfilled the criteria in the prior periods. In order to be able to interpret the effect of asset eligibility as causal, we need to verify that the common trend assumption holds. This assumption holds if eligible and noneligible assets behave similarly in the period prior to QE. We therefore apply the initial implementation provisions retrospectively. We observe that trades involving hypothetically eligible assets do not exhibit significantly different changes in repo rates prior to QE; eligible and noneligible collateral assets also respond similarly to changes in the monetary policy rate during that period. In the pre-QE period, the common trend assumption therefore holds. However, since the start of QE, repo trades involving eligible assets have a 17-basis-point lower sensitivity compared to noneligible collateral assets. This speaks to an effect caused by unconventional monetary policy. Our main Regression (3) captures both effects. The impact of changes in the monetary policy target rate on special repo rates is almost muted during QE, which is in particular driven by trades involving eligible assets. In the period after the introduction of QE, a decrease in the target rate by one percentage point implies a decrease in the rates of noneligible assets by five basis points more relative to eligible assets. While the overall size of this effect seems to be small, it represents a 50% reduction relative to the overall sensitivity of special repo rates to changes in the monetary policy rate.

Similar to the previous analyses, we perform a number of additional robustness checks to confirm our main results. First, columns 4–9 extend our analysis to core and all European countries, respectively. Second, we repeat our analysis for each term type and regional classification; third, for different standard error and fixed effect specifications; fourth, in a sample without quarter end and end of ECB maintenance period trading days and weeks; and finally, for a shorter sub-period until 2016. Overall, the results remain statistically and economically consistent.\footnote{All robustness checks are reported in the Online Appendix.}

To further understand the economic determinants of our results, we extend our analysis by looking at asset scarcity associated with unconventional monetary policy in more detail.
Table 5: Asset eligibility: Time since eligibility

<table>
<thead>
<tr>
<th></th>
<th>Germany (1)</th>
<th>Germany (2)</th>
<th>Germany (3)</th>
<th>Germany (4)</th>
<th>Germany (5)</th>
<th>Germany (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔPolRate</td>
<td>0.106***</td>
<td>0.106***</td>
<td>0.105***</td>
<td>0.105***</td>
<td>0.099***</td>
<td>0.099***</td>
</tr>
<tr>
<td>DQE</td>
<td>−0.015</td>
<td>−0.016</td>
<td>−0.008</td>
<td>−0.008</td>
<td>−0.020*</td>
<td>−0.020**</td>
</tr>
<tr>
<td></td>
<td>(−1.365)</td>
<td>(−1.409)</td>
<td>(−1.091)</td>
<td>(−1.146)</td>
<td>(−1.951)</td>
<td>(−1.987)</td>
</tr>
<tr>
<td>ΔPolRate · DQE</td>
<td>−0.093***</td>
<td>−0.120***</td>
<td>−0.080***</td>
<td>−0.104***</td>
<td>−0.070***</td>
<td>−0.082***</td>
</tr>
<tr>
<td>ΔPolRate · TSE</td>
<td>−0.001***</td>
<td>−0.001***</td>
<td>−0.001***</td>
<td>−0.001***</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(−9.655)</td>
<td>(−9.894)</td>
<td>(−10.604)</td>
<td></td>
<td></td>
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</tbody>
</table>

The table reports the regression results examining the impact of asset eligibility for quantitative easing on the monetary policy pass-through under particular consideration of the number of days an asset is eligible for purchase. The dependent variable is the change in the special repo rate $\Delta \text{repo}^{\text{Special}}$. $\Delta \text{PolRate}$ denotes the change in different policy rates. $DQE$ equals 1 during the PSPP. $TSE$ refers to the time since eligibility (i.e, the cumulative time an asset is eligible for purchase under the PSPP), which we split in three buckets: $TSE_{\text{Bucket}}^1$ for assets which have (cumulatively) been eligible for up to 200 days, $TSE_{\text{Bucket}}^2$ for assets which have been eligible for up to 400 days, and $TSE_{\text{Bucket}}^3$ for assets which have been eligible for more than 400 days. ***, **, and * represent significance at a 1, 5, and 10% level, respectively; $t$-statistics are in parentheses. All regressions include ISIN-month-term fixed effects and heteroscedasticity-robust standard errors. Data include special repo transactions for all European countries pooled across the term types TN and SN for the time-period 2010–2018.
Our idea is that asset scarcity is stronger for those assets which have been QE eligible for a longer period (since the ECB had more opportunities to purchase those securities). We therefore introduce a new variable “time since eligibility” (TSE) which captures the number of days an asset has been eligible for purchase under the PSPP.

Table 5 reports the regression results focusing on asset scarcity effects. We show two regression specifications: (i) by employing our new TSE variable, and (ii) by employing three TSE buckets with $TSE^1_{Bucket}$ for assets which have been QE eligible for up to 200 trading days, $TSE^2_{Bucket}$ for assets which have been eligible for up to 400 days, and $TSE^3_{Bucket}$ for assets which have been eligible for more than 400 days. For all regressions, we replace our previous $D_{t,i}^{Eligible}$ dummy with the newly introduced TSE variable, interacted with the log-change in the monetary policy rate $\Delta PolRate_t$.

Regression (1) relates changes in special repo rates to changes in the monetary policy target rate under consideration of the TSE variable. We observe that the monetary policy pass-through into repo rates is weaker for those assets that have been eligible for purchase for a longer period. A one-percentage-point change in the target rate translates into a 0.1 basis points lower sensitivity in special repo rates for each day an asset is eligible for purchase. To put this number into perspective: Assets which are 100 days eligible for purchase have a 10 basis points lower sensitivity. Regression (2) shows that the lower sensitivity of eligible assets is particularly driven by those assets which have been eligible for the longest period. For example, assets which have been eligible for less than 200 trading days do not show a significantly different sensitivity compared to assets which have never been eligible for purchase. However, assets which have been eligible for up to 400 days, have a 28-basis-point lower sensitivity. For assets which have been eligible for more than 400 days, the effect increases to 47-basis-points. The results are consistent for core and all European countries as shown in columns 3–6.

Clearly, our results speak to the role of asset scarcity, as assets which have been eligible for purchase by the ECB for a longer period (scarcer assets) are less sensitive to changes in $TSE$ is a continuous variable which increases by one if asset $i$ on day $t$ was eligible for purchase under the PSPP. If an asset was eligible in the past but is not at the moment, the TSE variable keeps its value.
the policy rate. This is in line with an upward movement in the demand curve for eligible assets.

3.4 Joint effects

So far, we have considered how access to central bank deposits and eligibility for QE programs impact the monetary policy transmission independently. Now we analyze whether bank’s access and QE jointly contribute to the monetary policy disconnect. To our knowledge, we are the first to analyze (i) the QE impact on GC repos and (ii) whether lending rates of access and nonaccess banks diverge in the special market.

In the GC market, certain baskets contain a higher share of collateral assets (out of the list of assets eligible to be delivered into a basket) that are eligible for asset purchases; thus, trading in these baskets increases the likelihood of sourcing collateral assets that have become scarcer due to QE programs. This implies that lenders might accept lower rates on those baskets, which would be an additional source of rate dispersion impeding the monetary policy pass-through. We therefore compute the share of securities eligible for QE programs within the pool of collateral assets potentially deliverable into a GC basket as an indicator for the likelihood of obtaining a QE eligible asset as collateral, even in a GC transaction. Our data features a cross-section of 46 GC baskets for which we compute, at each point in time, the share, weighted by issuance volume, of the securities that can be used as collateral that are also (hypothetically) eligible for central bank asset purchases.

For the panel regression, we ask whether baskets with a higher share of eligible securities react less strongly to changes in the monetary policy target rate, even after accounting for the banks’ access to the ECB’s deposit facility as a first form of market segmentation. For the regression, we follow the previously introduced approach for the GC market and newly introduce the dummy variable $D_{t,i}^{Eligible}$ for the GC market, which is equal to one if a basket $i$...
at time $t$ has a (hypothetical) eligibility share higher than the median eligibility share across all baskets of that country at time $t$. As before, we add basket-month-term fixed effects and employ heteroscedasticity-robust standard errors. We show our main results as a pooled regression of the term types ON and TN in Table 6. We report our results for (i) Germany in column 1a, (ii) core European countries in column 3a, and (iii) all countries in column 5a.

In addition to confirming our previous results, we find in Regression (1a) that trades involving baskets with high and low eligibility shares respond differently to changes in the monetary policy rate, even after controlling for the banks’ access to the deposit facility. Prior to the introduction of QE, baskets with a hypothetically higher share of eligible collateral assets tended to react slightly more. However, since the start of QE, repo trades involving baskets with a higher share of eligible securities are less sensitive to changes in the monetary policy target rate, more than undoing the baseline effect. In the period after the introduction of QE, an accommodative monetary policy with a decrease in the target rate by one percentage point is associated with a six-basis-point smaller decrease in the rates of baskets with a higher eligibility share relative to baskets with a lower eligibility share. Comparing the economic magnitude, access to central bank facilities remains the more pronounced effect.

In a GC repo, certain collateral assets may be more likely to be delivered than others. In particular, it is possible to identify the ‘cheapest-to-deliver’ collateral asset, which is the asset that commands the highest repo rate in the special market segment and thus features the smallest specialness. As an alternative to our volume-based measure of basket eligibility, we also employ the QE-eligibility of the cheapest-to-deliver bond as a measure of basket eligibility. The results based on this classification are reported for (i) Germany in column 1b, (ii) core European countries in column 3b, and (iii) all countries in column 5b. We find that our results are robust to this alternative specification.

We now turn to the joint effects on special repos. To do this, we perform a similar set of panel regressions as introduced for the GC market. In this regression setting, $D_{t,i}^{Eligible}$ equals one if security $i$ is (hypothetically) eligible for purchase under the PSPP. We add ISIN-month-term fixed effects and employ heteroscedasticity-robust standard errors. The
Table 6: Joint effects of both forms of segmentation

<table>
<thead>
<tr>
<th>(1a)</th>
<th>(1b)</th>
<th>(2)</th>
<th>(3a)</th>
<th>(3b)</th>
<th>(4)</th>
<th>(5a)</th>
<th>(5b)</th>
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</table>

\[ \text{Table 6: Joint effects of both forms of segmentation} \]

\[ \text{The table reports the regression results examining the simultaneous impact of ECB access and asset eligibility on the pass-through of the monetary policy target rate into GC and special repo rates. The dependent variable is the change in the GC rate \(\Delta \text{repo}^{GC}\), respectively the change in the special rate \(\Delta \text{repo}^{special}\). \(\Delta PolRate\) denotes the change in the policy rate. \(\Delta \text{repo}^{GC}\) equals 1 if a country’s average GC rate is below the deposit facility rate. \(\Delta \text{repo}^{special}\) equals 1 if a lending bank has access to the deposit facility. \(\Delta QE\) equals 1 during the PSPP. \(\Delta \text{Eligible}\) equals 1 in the GC segment in columns 1a/3a/5a if a basket is eligible. In the special segment \(\Delta \text{Eligible}\) equals 1 if a security is (hypothetically) eligible for purchase under the PSPP. Note, that the term \(\Delta PolRate \times \Delta QE\) was not included because it overlaps with \(\Delta PolRate \times \Delta \text{repo}^{special}\) which complicates the identification and interpretation of the two coefficients. Including \(\Delta PolRate \times \Delta QE\) leads to very similar results. ***, **, and * represent significance at a 1, 5, and 10% level, respectively; t-statistics are in parentheses. All regressions include basket/ISIN-month-term fixed effects and heteroscedasticity-robust standard errors. Data include GC and special repo transactions for Germany, core European countries and all European countries pooled across the term types ON, TN, and SN for the time-period 2010-2018.} \]
results for the pooled regression for the term types TN and SN are shown for (i) Germany in column 2, (ii) core European countries in column 4, and (iii) all countries in column 6.

Regression (2) confirms that both forms of market segmentation are also present in the special repo market. A one-percentage-point change in the monetary policy rate translates into a 19 basis point lower sensitivity of access banks relative to nonaccess banks during periods when the GC rate is below the rate on the deposit facility, and into a 10 basis point lower sensitivity of eligible collateral relative to noneligible collateral during the recent period of unconventional monetary policy. For a graphical comparison, the impulse response functions of access and nonaccess banks in the two market segments are depicted in Figure A.5.1 in the Appendix. Columns 3–6 expand our analysis by looking at larger samples. Again, the results remain statistically and economically consistent when we extend our sample to core and all European countries.

Overall, two new findings arise from the analysis of the joint effects: First, the pass-through of the monetary policy target rate in the GC market has been additionally impeded by the implementation of QE suggesting a pervasive effect of asset scarcity coming from QE on the entire repo market. Second, the monetary policy disconnect through special repos also depends on the access to central bank’s operations. Apparently, the co-existence of both forms of rate dispersion complicates the monetary policy implementation even further.

4. Alternative policy measures

To underline the robustness of our results we experiment with alternative policy rates. Our (i) baseline rate is the EONIA, a weighted average of the interest rates on unsecured overnight lending transactions denominated in euros, as reported by a panel of contributing banks. It is (indirectly) determined by the rates that the ECB sets on its standing facilities. In 2017, the ECB announced that the euro short-term rate (€STR) will replace the EONIA as the new short-term interest rate benchmark in the euro area. The €STR rate reflects the wholesale euro unsecured overnight borrowing costs of banks located in the euro area, and thus covers the borrowing cost of a larger set of banks as compared to the EONIA.
Historical €STR rates date back to March 13th, 2017. As a (ii) second rate, we therefore consider an EONIA-€STR combination with the €STR rate replacing the EONIA after its publication. As a (iii) third, unsecured reference rate, we consider the overnight euro LIBOR rate. Since monetary policy shapes expectations about future short-term interest rates, we also consider a set of derivatives-based, forward-looking overnight interest rates. We employ (iv) the overnight point of the Overnight Index Swap (OIS)–implied zero curve which uses one-month, three-month, and six-month OIS derivatives, as well as (v) the overnight point of the EURIBOR-implied zero curve, which uses one-month, three-month, and six-month EURIBOR derivatives. As an (vi) additional rate, we consider the one-week OIS rate.\footnote{Since we observe daily closing prices for the derivatives-based measures from Thomson Reuters/Refinitiv Eikon, we relate changes in policy rates over two days to daily rate changes in repo rates.} Finally, we employ the (vii) rate on the ECB GC Pooling basket, a secured rate. The GC Pooling basket is the primary GC funding basket, the basket not only enables the re-use of received collateral for central bank refinancing operations, it also features a large trading volume and no counterparty credit risk due to trading via a central counterparty.

Table 7 reports the results of our baseline specification in the GC market for the seven policy rates described above, Table 8 reports the results of our baseline specification in the special market. We present the results for German repo transactions for illustrative purposes.\footnote{The results for core and all European countries are presented in the Online Appendix.}

In the GC market, the estimations are statistically and economically consistent across all specifications. Three key results emerge from this analysis: First, GC repo rates are more sensitive to changes in unsecured overnight rates as compared to derivative-based implied overnight rates. This makes sense intuitively since we expect the conditions in the unsecured market to be a key determinant of trades in the secured market. In line with this intuition, the explanatory power of our panel regressions is largest for changes in unsecured overnight rates, which confirms our approach of employing the EONIA across our baseline specifications. Second, our results hold true if we employ a secured rate, the rate on the ECB GC Pooling basket, as our policy rate. This reinforces our interpretation that the monetary
Table 7: ECB access: Alternative policy measures

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<td>$\Delta PolRate \cdot D_{Dep}$</td>
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<tr>
<td>$D_{Access}$</td>
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| $N$                     | 10,007 | 10,007 | 9,958 | 9,848 | 9,615 | 9,938 | 9,988 |
| $R^2$                   | 0.220  | 0.220  | 0.188 | 0.131 | 0.129 | 0.156 | 0.308 |

The table reports the robustness results examining the impact of access to the ECB’s deposit facility on the monetary policy pass-through for alternative monetary policy target rates. The dependent variable is the change in the GC rate $\Delta repo^{GC}$. $\Delta PolRate$ denotes the change in different policy rates. $D_{Dep}$ equals 1 if a country’s average GC rate is below the deposit facility. $D_{Access}$ equals 1 if a lending bank has access to the deposit facility. ***, **, and * represent significance at a 1, 5, and 10% level, respectively; t-statistics are in parentheses. All regressions include basket-month-term fixed effects and heteroscedasticity-robust standard errors. Data include German GC repo transactions pooled across the term types ON and TN for the time-period 2010-2018.
Table 8: Asset eligibility: Alternative policy measures

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<td>0.109***</td>
<td>0.104***</td>
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<td>−0.016</td>
<td>−0.039***</td>
<td>−0.028**</td>
<td>−0.030**</td>
<td>−0.039***</td>
<td>−0.014</td>
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<td>−0.115***</td>
<td>−0.109***</td>
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<td>(0.428)</td>
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<td>−0.005</td>
<td>0.000</td>
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<td>−0.044**</td>
<td>−0.023</td>
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<td>(−0.998)</td>
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</table>

N: 301,766 301,766 300,047 295,606 289,216 299,622 301,192
R²: 0.116 0.116 0.117 0.116 0.116 0.114 0.123

The table reports the robustness results examining the impact of asset eligibility for quantitative easing on the monetary policy pass-through for alternative monetary policy target rates. The dependent variable is the change in the special repo rate Δrepo\_special. ΔPolRate denotes the change in different policy rates. D\_QE equals 1 during the PSPP. D\_Eligible equals 1 if a security is (hypothetically) eligible for purchase under the PSPP. ***, **, and * represent significance at a 1, 5, and 10% level, respectively; t-statistics are in parentheses. All regressions include ISIN-month-term fixed effects and heteroscedasticity-robust standard errors. Data include German special repo transactions pooled across the term types TN and SN for the time-period 2010–2018.
policy disconnect stems from institutional differences within the central bank framework as opposed to a segmentation between the secured and unsecured market segments. And third, all regressions arrive at the same conclusion, that is, access banks are less sensitive to changes in monetary policy target rates, in particular, when the GC rate is below the rate on the deposit facility.

Our results on special repos are also consistent if we employ alternative policy measures. Again, special repo rates are more sensitive to changes in unsecured overnight rates as compared to derivative-based implied overnight rates. Overall, the results confirm that eligible securities are less sensitive to changes in monetary policy target rates since the start of the ECB’s QE program. This lower sensitivity has not been present in prior periods.

5. Dispersion and lending rates

So far, we have focused on the first step in the monetary policy transmission pipeline, the pass-through of monetary policy into the money market, and discussed to what extent this is inhibited by the central bank framework. Although we are primarily interested in the first step of the monetary policy transmission pipeline, we now conduct some preliminary analysis of the 2nd and 3rd step.

One prime indicator for pass-through inefficiency in money markets has been proposed by Duffie and Krishnamurthy (2016, p.36): a volume-weighted absolute dispersion index. Inspired by this, we present dispersion measures for the GC and special repo market segments in Figure 6 which we accordingly refer to as ‘DK index’.

We observe that the dispersion in the GC segment increases once the GC rate drops below the rate on the deposit facility (as indicated by the grey shaded area). Similarly, we observe an increase in the dispersion in the special segment since the introduction of QE that has further increased with extensions and expansions of the QE program. Both indices point towards rate dispersion and a weakening in the monetary policy transmission associated with the two features of the central bank framework which we analyze, i.e., access to central bank facilities and QE eligibility.
The figure depicts two DK dispersion indices defined as the volume-weighted average of the absolute deviation of repo rates from the volume-weighted mean repo rate in the spirit of Duffie and Krishnamurthy (2016, p.36). For the first DK index in the special market, we differentiate between rates on repos secured by eligible and noneligible collateral. For the GC segment, we consider rates of trades involving access and nonaccess lenders.

Figure 6: Repo market dispersion
The second and third step of the monetary policy pass-through pipeline consider how the conditions in the money market ultimately impact the lending conditions faced by businesses and consumers. The interest rate environment plays an important role in investment and price setting decisions. As bank loans are the main source of funding for large parts of the economy, the pass-through of monetary policy to the banking sector is crucial. To highlight the importance of the repo market for the monetary policy transmission into the real sector, Figure 7a shows the co-movement of GC and special repo rates with a GDP-weighted average Eurozone government bond yield, while Figure 7b illustrates for Germany that repo rates correlate with credit conditions faced by corporate borrowers and private households. The graphical intuition points towards the repo market playing an important role in the transmission of monetary policy into borrowing costs of the public debt and bank lending rates, which is why it is important to monitor the repo market for indications of distress that could inhibit the second and third steps of the pass-through process.

Figure 7: Interest rate co-movements

To formalize this idea in a simple empirical setting, we examine the pass-through of changes in the monetary policy target rate into lending rates faced by corporate borrowers
and private households, depending on the conditions in the repo market resulting from policy conditions and the monetary policy framework. The dependent variable is the change of a given lending rate \( \Delta r^L \), for which we consider borrowing costs of non-financial firms and loans to households for house purchases. \( \Delta PolRate \) denotes the change in the policy rate (EONIA). \( D^{DK_{GC}} \) equals 1 if the dispersion measure for the GC market is above its median, while \( D^{DK_{Special}} \) equals 1 if the dispersion measure for the special market is above its median. Lastly, we consider the dummy \( D^{DK_{Repo}} \) which equals 1 if either of the two GC and special repo market dispersion measures is 1.

Table 9 reports the results of our panel regressions. Regressions (1) relates changes in non-financial corporate borrowing rates to changes in the monetary policy target rate, depending on the dispersion in GC and special repo rates; regression (2) considers our repo market dispersion dummy. The results highlight that lending rates react strongly: A one-percentage-point decrease in the target rate is accompanied by a decrease in corporate borrowing rates of about 50 basis points. The effect is, however, almost muted when the dispersion in repo rates is high. Regression (3) and (4) confirm our results for residential housing rates. In all regressions, we account for country-year fixed effects.

Our results provide empirical support for Duffie and Krishnamurthy (2016) who highlight that a dispersion across money market interest rates is a primary indicator of the inefficiency of monetary policy pass-through. Although the monetary policy transmission into the real economy involves additional steps that deserve a detailed analysis beyond short-term rates, our results clearly speak to the importance of the repo market for the monetary policy transmission. Since the repo market is the predominant source of short-term funding, the repo market determines bank funding conditions and ultimately impacts the transmission of monetary policy into the real sector. We therefore propose the DK-measure as a new empirical indicator to capture monetary policy pass-through inefficiency in the euro area. Our results document that the monetary policy disconnect is associated with an increased dispersion in

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40 We also show in the Online Appendix that our results remain statistically and economically consistent if we consider other policy rates that the ECB could target and if we shorten the sample period to the end of 2016.
Table 9:Repo dispersion and the pass-through to lending rates

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<td>Housing ∆r&lt;sub&gt;L&lt;/sub&gt; b/t</td>
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<td>(3.431)</td>
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<td>R²</td>
<td>0.126</td>
<td>0.125</td>
<td>0.174</td>
<td>0.173</td>
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The table reports the regression results examining the pass-through of changes in the monetary policy target rate into lending rates faced by corporate borrowers and private households. The dependent variable is the change of a given lending rate ∆<sub>r<sub>L</sub></sub>. Non-financial corporate borrowing rates refer to the annualized borrowing costs of non-financial firms for new loans, while new housing rates refer to bank interest rates on new loans to households for house purchases with an initial rate fixation period of between one and five years. Both lending rates are available from the ECB’s monetary financial institutions (MFI) interest rate statistics. ∆PolRate denotes the change in the policy rate (EONIA). D<sub>DKG</sub>C equals 1 if the dispersion measure for the GC market is above its median. D<sub>DSpecial</sub>C equals 1 if the dispersion measure for the Special market is above its median. D<sub>DR</sub>Repo equals 1 if any of the GC and special repo market dispersion measures is above its median. ***, **, and * represent significance at a 1, 5, and 10% level, respectively; t-statistics are in parentheses. All regressions include country-year fixed effects and standard errors accounting for clustering at the year level. Data are at a monthly frequency for all European countries for the time-period 2010–2020.
repo rates that reduces the sensitivity of lending rates to changes in the monetary policy rate.

6. Conclusion

Monetary policy is most effective if money market rates react consistently and uniformly to the monetary policy stance. We point out that two key aspects of the current central bank framework lead to a dispersion in money market rates thus weakening the transmission of monetary policy.

The first aspect of the central bank framework relates to banks’ access to the central bank’s deposit facility. We show that those banks with access lend at short-term rates that are more misaligned from the monetary policy target rate when repo rates are below the deposit facility rate. This new finding provides a novel perspective for assessing the effectiveness of monetary policy transmission depending on who has access to the central bank’s facilities. Its consequences are relevant for some recent policies. For instance, the European Commission issued amendments to the Capital Requirements Regulation (CRR), at the heart of which is the (temporary) exclusion of central bank reserves from the calculation of the leverage ratio (European Commission, 2020). Similarly, the two-tier system partially exempts banks from negative rates currently applicable on the deposit facility. Both measures could encourage further accumulation of central bank reserves, thereby weakening the monetary policy transmission.

The second aspect of the central bank framework relates to unconventional asset purchasing programs. We show that secured loans whose collateral assets are the target of Quantitative Easing programs are more disconnected from the monetary policy rate. The notion that unconventional policies “safeguard the transmission of our monetary policy,” as pointed out by ECB President Christine Lagarde (European Central Bank, 2020) should also consider that those programs can indeed create rate dispersion leading to unintended consequences such as the monetary policy disconnect.
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Appendix

A.1 Monetary policy

The figure depicts the development of the rates on the deposit and marginal lending facility as well as the EONIA rate. The rates on the deposit and marginal lending facility define the corridor for the EONIA as the unsecured, overnight interest rate at which banks lend to each other.

Figure A.1.1: Interest rate corridor
A.2 Theoretical mechanisms at work

Building on the framework proposed in Duffie (1996), we illustrate how the two features of the central bank framework affect the decision problem of banks operating in the GC and special repo market in a supply and demand diagram. While Duffie (1996) focuses on the special market, we extend his framework to GC repos. Note, that we are considering the first, short-run step of the transmission process, while other recent papers such as Wang (2018) consider the longer-run impacts of an inhibited monetary policy transmission, such as the impact on inflation.

Figure A.2.2 depicts the supply and demand diagram in the GC market: the x-axis shows the GC rate, the y-axis the quantity (per institution). The borrower in the GC market is searching for funding, the supply curve therefore has a negative slope (i.e., the lower the repo rate on a loan, the larger the supply of collateral to be temporarily sold to borrow funds). On the demand side, we present two distinct demand curves: one for access banks and one for nonaccess banks. This is needed since the decision problem of those two types of banks is different; one is able to deposit funds at the deposit facility while the other is not.

The demand of nonaccess banks for investing liquidity is inelastic. While we do not model the behavior of nonaccess banks explicitly, this is suggested for several reasons: First, banks without central bank access face the decision problem of investing in the secured or unsecured money market. Repos are mostly secured by government bonds, which are safe assets per se, carrying convenience yields in the form of safety and liquidity benefits. The benefits from obtaining collateral (Piquard and Salakhova 2019) therefore create a net demand for safe assets (Infante 2020), which is particularly inelastic when QE programs render them scarce. Second, financial regulation incentivizes directly and indirectly banks to hold secured deposits (Ranaldo et al. 2021). Finally, capacity constraints as well as limits to arbitrage in the unsecured money market can even lead the unsecured rate to fall below the secured rate (Nyborg 2019), rendering unsecured investments unattractive. Access banks can always

\[41\text{In the traditional model of Duffie (1996), the supply curve is upward-sloping since the x-axis shows the “specialness” instead of the GC rate (reverse direction).}\]
Figure A.2.2: Impact of supply shock in the GC repo market

Figure A.2.3: Impact of demand shock in the special repo market
access the deposit facility. This option becomes more attractive when the GC rate falls below the rate on the deposit facility, leading to a lower demand of access banks. We illustrate this change in the demand via a kink in the demand curve.\textsuperscript{42} The demand of access banks to deposit liquidity in the repo market does not immediately vanish due to benefits of obtaining collateral over holding cash, for example, to pledge it in margin accounts.\textsuperscript{43}

Since the start of QE, excess liquidity in the euro area has strongly risen (e.g., Arrata, Nguyen, Rahmouni-Rousseau, and Vari 2020). This is graphically illustrated in a negative supply shock, that is, fewer banks need to borrow liquidity in the repo market. Two effects emerge from this negative supply shock: First, GC rates can fall below the rate on the deposit facility. This leads access banks to deposit an increasing share of their liquidity at the deposit facility, thus the size of the GC market and the trading share of access banks in the GC market declines. Second, and important to our regression analysis, interest rates between access and nonaccess banks diverge in the sense that the former institutions tend to lend at rates closer to the central bank deposit rate. As preliminary evidence, Figure 3a shows the decline in the size of the GC market accompanied by a decrease in the trading share of access banks, while Figure 3b illustrates the difference in GC rates by access status.

Figure A.2.3 depicts the supply and demand diagram in the special market: the x-axis now shows the special rate, the y-axis the quantity (per bond). In the special market, the trading behavior is characterized by the collateral leg of the repo transaction: Following Duffie (1996), some security holders are only willing to lend (supply) those securities at a premium (i.e., at a repo rate below the GC rate). This translates into a negatively sloped supply curve. The demand in the form of short sellers is completely inelastic. Asset purchases of eligible securities have led to asset scarcity and an additional demand for eligible assets (Bank for International Settlements 2017, p.16). This is graphically illustrated in two demand curves,

\textsuperscript{42}To provide empirical evidence for the kinked demand curve, we show that the share of access banks as lenders in repo transactions declines once the GC rate falls below the deposit facility rate (since access banks can place their funds at the central bank), while their share as borrowers remains constant (Section A.4 in the Appendix).

\textsuperscript{43}The current spread at Eurex on cash denominated in euro pledged in margin accounts is, for example, 20 basis points, thus rendering cash collateral less attractive (https://www.eurex.com/ec-en/services/collateral-management/cash-collateral/interest-rates-on-cash-collateral).
one at a higher level (for eligible assets) and one at a lower level (for noneligible assets). Two effects emerge from this positive demand shock for eligible assets: First, the size of the special market increases with an increasing share of trading in eligible (collateral) assets. Second, repo rates diverge as rates for eligible assets fall below those for noneligible assets (i.e., eligible asset is more “special”). Figure 4a shows the increase in the size of the special market accompanied by an increase in the trading share in eligible assets, while Figure 4b illustrates that repo rates for eligible assets have fallen below repo rates for noneligible assets since the start of QE.
A.3 Deposit facility volume

The figure depicts the spread between the German GC rate and the ECB’s rate on the deposit facility as well as the total volume deposited at the ECB deposit facility.

**Figure A.3.1:** Deposit facility volume and spread between GC and deposit facility rate
A.4 Access banks trading behavior

Repo rates have been lower than the deposit rate for an extended period of time. This leads to two related questions: (1) whether an arbitrage opportunity for access banks exists by borrowing in the repo market and storing the borrowed funds at the deposit facility and (2) why access banks nonetheless continue to lend in the repo market. Although an exhaustive answer to this question deserves research in its own right, some brief consideration must be given.

First, this direct comparison of the repo rate and the deposit rate errs in assuming that central bank reserves are equivalent to repo loans and abstracts from the value of the collateral. A bank engaging in such a seemingly arbitrage trade needs to hold the collateral (e.g., a scarce German Bund) to secure the repo borrowing and by delivering it into a repo foregoes its service flows, which can be interpreted as an opportunity cost of the trade. Second, there is evidence that a spread between the repo rate and deposit rate attracts this sort of arbitrage trading but to a limited extent, e.g., due to small margins and other regulatory costs (Ranaldo et al., 2019). Third, obtaining collateral is not only a motivation for trading in the special market but also in the GC segment explaining why access banks still trade in the GC market when GC rates fall below the rate on the deposit facility.

We conduct a preliminary analysis showing that once the average GC rate falls below the deposit facility rate, access banks reduce their cash lending and concentrate it to trade in either baskets of high-quality collateral (such as German Bunds) or lower quality baskets that are still trading above the deposit facility rate. Since 2015, when repo rates fell below the rate on the deposit facility, GC trading volume declined to about a third of its original size. Figure A.4.1a depicts the trading share of access banks in GC repo transactions collateralized by German government bonds.

These results suggest that there are two reasons why access banks still lend in the GC segment even when average GC rates are below the deposit facility rate: First, they attribute a higher marginal value on high quality collateral and for this they are willing to receive a lower interest rate. Second, the higher lending rates associated with lower quality baskets
Figure A.4.1a depicts the trading share of access banks in GC repo transactions collateralized by German government bonds. Figure A.4.1b depicts the share of access banks among borrowers and among lenders in the German GC market.

**Figure A.4.1:** Trading shares of access banks

represent a lucrative opportunity to store funds.

In section A.2 we argue that the GC market is characterized by a kinked demand curve from access banks while the demand from nonaccess banks is inelastic. We thus conclude that the increase in trading share by nonaccess banks results from fewer lending activities by access banks. This can be observed in the data, as shown in Figure A.4.1b. In this graph, we depict the share of access banks among borrowers and among lenders in the GC market. While we observe that the share of access banks among borrowers has been stable over time, we observe that the share of access banks among lenders has dropped in recent years. Thus, the drop in trading by access banks has been caused by a reduction in their lending activity.
A.5 Nonaccess banks in the special market

The figure depicts the impulse response function of repo rates to changes in the monetary policy target rate for trades involving access and nonaccess banks in the GC market (left panel) and the special market (right panel). The coefficients are derived from a time series regression of current repo rate changes on the concurrent and the ten preceding monetary policy rate changes controlling for basket-time or ISIN-time fixed effects. The regression includes heteroscedasticity-robust standard errors.

Figure A.5.1: Impulse response for German trades in the GC and special market involving access/nonaccess banks