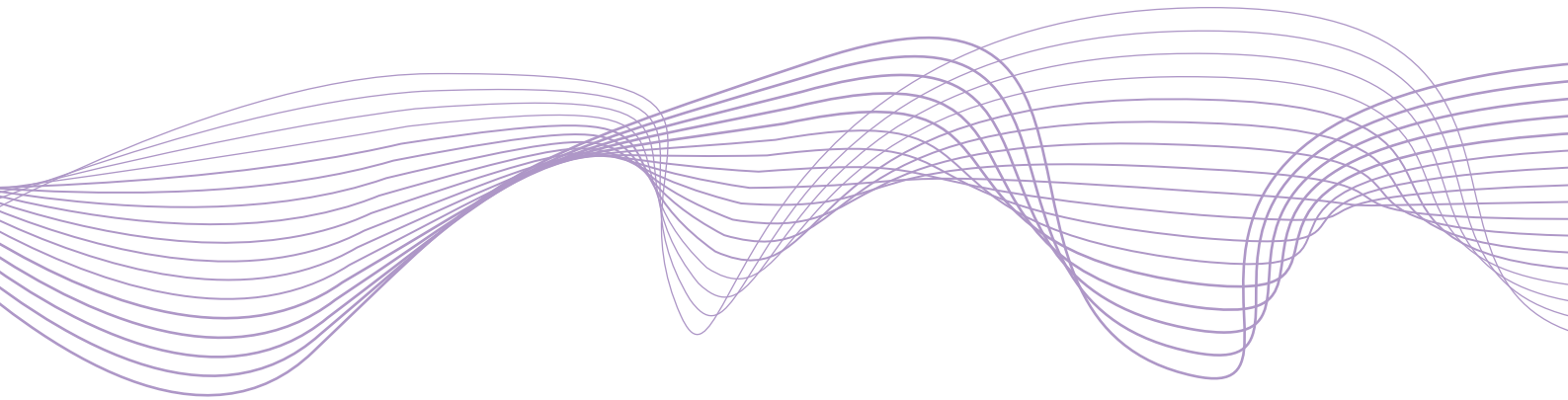
Working Paper Series

No 55 / October 2017

Collateral scarcity premia in euro area repo markets

by
Massimo Ferrari
Claudia Guagliano
Julien Mazzacurati



ESRB
European Systemic Risk Board
European System of Financial Supervision

Abstract

Collateral plays a very important role in financial markets. Without easy access to high-quality collateral, dealers and market participants would find it more costly to trade, with a negative impact on market liquidity and the real economy through increased financing costs. The role of collateral has become increasingly significant since the global financial crisis, partly due to regulatory reforms. Using bond-level data from both repo and securities lending markets, this paper introduces a new measure of collateral reuse and studies the drivers of the cost of obtaining high-quality collateral, i.e. the collateral scarcity premium, proxied by specialness of government bond repos. We find that the cost of obtaining high-quality collateral increases with demand pressures in the cash market (short-selling activities), even in calm financial market conditions. In bear market conditions – when good collateral is needed the most – this could lead to tensions in some asset market segments. Collateral reuse may alleviate some of these tensions by reducing the collateral scarcity premia. Yet, it requires transparency and monitoring due to the financial stability risks associated. Finally, we find that the launch of the ECB quantitative easing programme has a statistically significant, albeit limited, impact on sovereign collateral scarcity premia, but this impact is offset by the beginning of the ECB Securities Lending Programme.

JEL Classifications: E52, G12, G23

Keywords: Repos, securities lending, collateral, specialness, short selling, collateral reuse, negative interest rates, quantitative easing.

1. Introduction

Since the financial crisis, the demand for collateral assets has increased in the financial system, also due to recent market and regulatory developments[1]. Collateral flows lie at the heart of any proper understanding of market liquidity, and hence of financial stability (Singh, 2016). In Europe, securities financing transactions (SFTs)[2] account for more than 80% of collateral flows in large EU banks (ESRB, 2014) and therefore play a key role in supporting collateral fluidity – i.e. securities being in the right place, at the right time – by ensuring that collateral is efficiently allocated to counterparties that need it the most, for regulatory and business purposes. The objective of this paper is to shed further light on the functioning of SFTs in the Euro area, by developing a new proxy for collateral reuse and by analysing the drivers of the cost of obtaining high-quality collateral, proxied by specialness in repo markets.

We analyse the repo and securities lending markets for seven Euro area sovereign issuers, between March 2013 and September 2015. We focus on specialness in government bond markets, which is a proxy for the cost of obtaining high-quality collateral. Specialness is defined as the difference between the rates on General Collateral (GC) repos and special repos, and it is a proxy for the scarcity premium to be paid for procuring a specific security (Duffie, 1996). In repo markets, the collateral becomes special and trades at a lower rate when it is on high demand or in limited availability. We highlight how bond-specific supply and demand affect specialness in the repo market: In particular, we analyse empirically the impact of collateral reuse and short selling activity on the collateral scarcity premium.

We build on the seminal paper of Duffie (1996), by empirically showing that specialness is related to:

1) The liquidity of the instrument: of two otherwise identical instruments, the most liquid one is more likely to be on special, that is, to be traded at lower repo rates;
2) Short selling activity: specialness increases with the demand for short positions, for a given total supply of securities.

Within this framework, we analyse the auction cycle and trade life-cycle of government bonds, also introduced in Duffie (1996). In line with the recent literature, our findings show that the collateral scarcity premium of a bond is sensitive to the announcement of a new auction, and to the auction itself. We also highlight the behaviour of specialness based on a bond's trade life-cycle, reflecting differences in the trading of on-the-run and off-the-run government bonds in repo markets.

We contribute to the recently growing literature analysing the functioning of repo markets in Europe. Mancini et al. (2015) empirically show that centrally-cleared repos secured by high-quality collateral acted as a shock absorber during financial crisis. Boissel et al. (2015) build on these conclusions, and find that central counterparties (CCPs) provided some protection in periods of moderate sovereign stress (2009-2010) but were unable to restore stability on

[1] Regulatory drivers of increased collateral demand include: Basel III/CRD4 requirements, e.g. requirements to hold high-quality liquid assets for Liquidity Coverage Ratios; OTC derivatives reforms (EMIR) through the mandatory clearing of certain classes of derivatives and collateral and margin requirements for CCPs and bilateral derivatives transactions; expansion of central banks' balance sheet through increased collateral eligibility for central bank funding and securities purchases; and a broad market shift from unsecured to secured funding.

[2] SFTs include mainly repos and securities lending transactions.

the repo market in times of high sovereign stress (2011) in the countries most affected by the crisis. Both papers focus on GC repos, analysing the role of the repo markets as financing means for market participants. We look instead into the other economic function of repos, which is to allocate high-quality collateral in the system and primarily takes place through the *special collateral* repo market segment. Therefore, our paper is closest to Corradin and Maddaloni (2016), which focuses on specialness in the repo market for Italian sovereign collateral from October 2009 to July 2012, and to Aggarwal et al. (2016), which analyses the role of securities lending markets for EU government bonds in collateral transformation[3].

The main innovation of our paper is the introduction of a novel measure of collateral reuse. Most SFTs in Europe are title-of-transfer agreements that give full right of reuse to the collateral taker, which has become a widespread practice in EU financial markets.[4] This proxy allows us to estimate empirically for the first time the impact of collateral reuse on special repo rates. By increasing the effective supply of securities that are in high demand and addressing potential shortages in the system, collateral reuse reduces consistently the scarcity premium on high-quality collateral in repo markets. Therefore, our paper contributes to the policy debate on collateral reuse by highlighting some of its potential benefits, in particular during periods of stress, when access to high-quality collateral is needed the most.

We also innovate with respect to the existing literature by carrying out for the first time a joint empirical analysis of the repo and securities lending markets across seven Euro area countries, focusing on the drivers of specialness. There is indeed strong overlap between special repos and securities lending markets, which – unlike GC repos – are both driven by the need to borrow and lend specific securities. The period analysed extends from 7 March 2013 to 21 September 2015 which, though relatively short, includes two fundamental changes of monetary policy: the introduction of negative interest rates on the ECB deposit facility, and the launch of ECB quantitative easing (QE) programme. Our paper thus sheds light on the impact of these two policy measures on high-quality collateral availability in Euro area repo markets, and analyses the role of the ECB securities lending programme in addressing potential collateral shortages from QE.

The paper is organized as follows: Section 2 reviews the relevant literature and describes the European securities financing transactions markets. Section 3 introduces the dataset and the empirical model and section 4 presents the empirical results. Section 5 provides evidence of the dynamics of specialness around monetary policy changes and Section 6 concludes.

2. Literature review and market overview

2.1 Literature review

We investigate the drivers of the cost of obtaining high-quality collateral, i.e. the collateral scarcity premium, proxied by the degree of specialness in Euro area government bond repo markets. An increase in repo specialness may signal a shortage of high-quality collateral, with a potentially negative impact on liquidity, capital markets financing, bank lending and the real economy.

[3] Collateral transformation (or "collateral upgrades") is a process that involves the exchange of low-quality securities (e.g. equities or low-graded bonds) against high-quality securities (e.g. government bonds).

[4] This is different from the US, where reuse rights are strictly limited.

A shortage of high-quality collateral may in turn reflect a combination of structural and cyclical factors. The structural factors that can impact the availability of collateral include technological changes, regulatory changes, changes in business models, and the development of services related to collateral management.

Our paper focuses on the cyclical factors, such as higher collateral demand, e.g. in the context of safe-haven purchases and short sales, liquidity, and reduced collateral availability, e.g. due to market participants withholding assets or central bank purchases. The repo specialness of a given instrument is defined as the difference between the reference GC rate and the special rate for that instrument.[5]

The pioneering theoretical paper of Duffie (1996) shows that one of the drivers of specialness is short selling: when traders short bonds in the cash market, they simultaneously enter reverse repo transactions to have the securities delivered in time for settlement. In other words, specialness is increasing in the amount of short selling activity in the cash market. Duffie also relates specialness to the liquidity of an instrument: of two otherwise identical instruments, the most liquid one is more likely to be on special, that is, to be traded at lower repo rates. Liquid bonds are more frequently shorted and consequently in greater demand as collateral in repo transactions. Vayanos and Weill (2008) build on this insight by showing that higher liquidity induces short-seller concentration and creates specialness.

The trade-life cycle of a bond is of particular relevance to specialness: On-the run bonds are typically more special (i.e. they trade at lower rates) due to their liquidity premium (Duffie, 1996; Krishnamurthy, 2002). An alternative interpretation is that on-the-run bonds trade “on special” in repo markets because they can be easily borrowed or purchased: risk averse short-sellers value their superior liquidity because they can be easily located when brokers later need to purchase these securities to close out the short position (Graveline and McBrady, 2011). The difference in specialness between off-the-run and on-the-run bonds can also reflect auction tightness and interest rate volatility (Moulton, 2004). In particular, increases in interest rate volatility positively contribute to the degree of specialness (Dufour and Skinner, 2005).

Our paper empirically investigates Duffie’s framework in the context of Euro area government bond repo markets. In line with the existing literature, which focuses mainly on the US Treasury repo market, we confirm the existence of a statistically significantly relationship between specialness and two main drivers: short-selling activity in cash bond markets, proxied by the utilisation rate of Euro area government bonds, and the liquidity of underlying securities, through the auction and trade life-cycles. On the other hand, higher secondary market liquidity of the sovereign bond used as collateral in repo transactions, measured by lower bid-ask spreads, is generally not associated in a statistically significant way with higher specialness.

Since Duffie (1996), a number of other hypotheses have been tested to better understand the drivers of specialness.[6] Among these is the important idea that the scarcity of the underlying securities should be one of the main determinants of repo rates. D’Amico et al. (2014) quantify the scarcity value of US Treasuries collateral by estimating the impact of security-specific

[5] According to ICMA, General Collateral (GC) is the range of assets that are accepted as collateral by the majority of intermediaries in the repo market, at any particular moment, at the same or a very similar repo rate. For more details on GC and special repos, see section 2.2.

[6] One stream of the literature not investigated here but important for future empirical research on repo markets is the relationship between repo rates, collateral quality and counterparty credit risk (see for example Hordahl et al. (2008) and Gorton and Metrick (2012), or Eren (2014) and Infante (2015) on repo rates and haircuts).

demand and supply factors on the repo rates of all outstanding Treasuries securities. Their results point to the existence of an economically and statistically significant scarcity premium, especially for shorter-term securities. They also provide additional evidence of the scarcity channel based on the Federal Reserve's quantitative easing programmes and suggest that, through the same mechanism, the Fed's reverse repo operations could help alleviate potential shortages of high-quality collateral. Our paper investigates collateral scarcity in the context of Euro area repo markets and the impact of the ECB QE and securities lending programmes on specialness.

Another branch of the literature examines the relationship between repo rates and the term structure. Longstaff (2000) tested the expectation hypothesis using short-term repo rates, finding that repo rates (up to a month) are not significantly different from the average expected overnight rate. The author concludes that much of the apparent term premium at the very short end of the repo market is due to other factors, such as liquidity. Buraschi et al. (2002), focusing on German government repo market, tested empirically the relation between the current term structure of long-term repo spreads (defined as the difference between GC and special rates), and the future collateral value of German government bonds. They found that current forward spreads overestimate changes in future specialness, and that deviations from the expectations hypothesis of interest rates are due to time-varying risk premium, such as liquidity risk.

Our paper also investigates the term structure issue. We do not find a robust statistically significant relationship between specialness and the term structure, either when considering the time-to-maturity of the underlying bond collateral or the differences in the original maturity of on-the-run bonds.

Finally, our paper contributes to the recently growing literature analysing the functioning of repo markets in Europe. Dufour and Skinner (2005) examine repo specialness for bonds used as collateral in the Italian government BTP repo market. They conclude that supply and demand are significant factors determining the degree of specialness. Moreover, as in Duffie (1996) they show that more liquid bonds trade more frequently on special and, as in Moulton (2004), that market conditions such as interest rate volatility increase specialness. Mancini et al. (2014), empirically show that centrally-cleared repos secured by high-quality collateral proved resilient and acted as a shock absorber in Europe during the financial crisis. In the same vein, Boissel et al. (2015), using a broader range of data, find that during the sovereign debt crisis of 2011, repo rates strongly responded to changes in sovereign risk perception, in particular for EU peripheral countries, also reflecting significant CCP default risk. Both papers focus on GC repos, analysing the role of the repo markets as financing means for intermediaries.

Our paper looks instead into the other main economic function of SFTs, which is to efficiently allocate high-quality collateral in the system, and primarily takes place through the special repo market segment. Therefore, our paper is closest to Corradin and Maddaloni (2016), who focus on specialness in the repo market for Italian sovereign collateral over the period going from October 2009 to July 2012. They find the scarcity premium to be higher in the repo market for bonds when the amount of a security that is effectively available in the market is lower, showing that this effect is stronger during periods of significant market stress. However, our paper differs in one main respect: Since special repos are driven by the need to borrow and lend specific securities, we investigate specialness using the strong overlap between

securities lending markets and the special repo market segment. Aggarwal et al. (2016) already established a link between securities lending and repo markets. Focusing on the Italian market, they find that more borrowing of a bond in the securities lending market relates to higher trading activity for that bond in the GC repo market, for the purpose of obtaining financing.

We innovate with respect to these two papers by carrying out, for the first time, an empirical analysis of the drivers of specialness in several Euro area countries, exploiting at bond level the overlap between securities lending market and the special repo market segment. We complement this framework by introducing a novel measure of collateral reuse. Although several papers already include collateral reuse in theoretical models (for example Bottazzi et al. (2012) and Infante (2015)), very few have actually attempted to analyse it empirically, mainly due to the lack of data. For example, Fuhrer et al. (2015) study the empirical relationship between collateral scarcity and reuse, focusing on the Swiss Franc repo market. Based on a proxy for collateral reuse in securities lending markets, our paper further investigates this issue in the Euro area. By increasing the effective supply of securities that are in high demand and addressing potential shortages in the system, collateral reuse consistently reduces the scarcity premium on high-quality collateral in Euro area repo markets.

2.2 Market overview and policy context

Main features of European securities financing markets

The main types of SFTs are repos and securities lending. Repos, or repurchase agreements, are contracts for collateralised borrowing and lending that are often used to finance long and short positions. A repo transaction combines a spot market sale of a security with a simultaneous forward agreement to buy back the same security at a later date. The repo rate is an annualised interest rate capturing the difference between the purchase and repurchase prices. There are two main types of repos: GC repos and special repos.

GC collateral assets are homogeneous liquid securities used indiscriminately by market participants for a certain rate (the GC rate) driven by standard supply and demand dynamics. In GC repos, the choice of collateral to be delivered is made after the trade from a collateral pool (i.e. a basket of securities meeting certain eligibility criteria). Special collateral repos, on the other hand, are repos in which the collateral is known before the trade is executed and has specific characteristics. Unlike GC collateral, there is no right of substitution in special repos, i.e. the right to return equivalent securities. When securities are in high demand on cash markets, they become special and buyers bid competitively for them by offering a higher price. This implies that special repo rates are lower than the reference GC rates.[7] Therefore, special collateral repos are security-driven transactions, while GC repos are cash-driven.

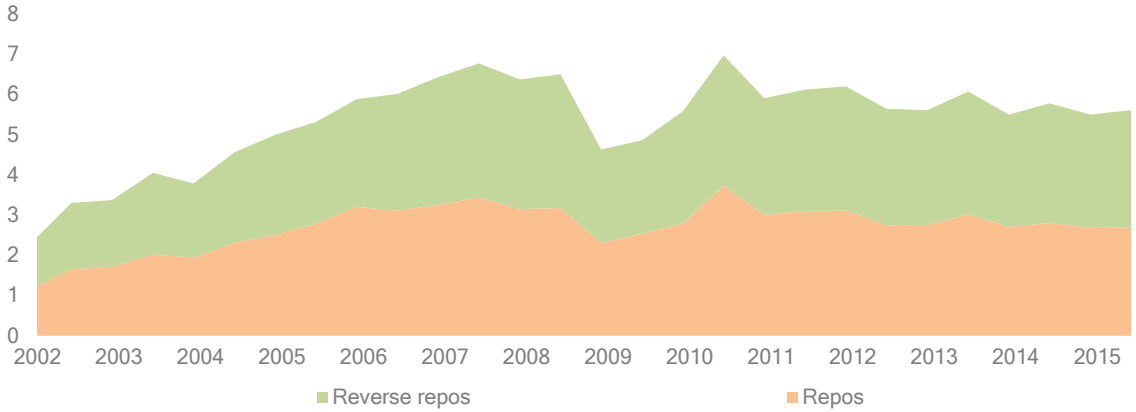
Repos are bilateral or tri-party transactions that are mainly traded OTC. In tri-party repos, an agent (e.g. a custodian bank) facilitates the transaction while taking care of post-trading services such as collateral management, settlement, and collateral valuation. The bilateral repo market is primarily interdealer, while the tri-party repo market brings together dealers and customers and is used to a large extent for repos based on collateral other than government

[7] In Duffie (1996), simple arbitrage with cash bond markets automatically prevents the possibility that special collateral trades at a higher repo rate than general collateral.

bonds (ESMA (2016)). As of the end of 2015, the European repo market size was around EUR 5.5tn[8] down from a peak of EUR 6.8tn in June 2007 (based on a survey of large European financial institutions by ICMA; Chart 1). Overall, daily volumes in Euro area centrally-cleared sovereign repos exceed EUR 300 bn.

The structure of European repo markets is different from that of the US. In the Euro repo market, transactions are mostly intermediated via automated trading systems and CCP-cleared, while the share of the tri-party repo market segment is relatively small. As of 2015, 66% of the Euro area repo market consisted of CCP-based bilateral repos, 26% of non-CCP based bilateral repos and less than 10% of triparty repos (ECB, 2015). There are three main electronic trading platforms constituting the CCP-based Euro interbank repo market: Eurex Repo, BrokerTec and MTS.

Chart 1: Gross size of the European repo market



Note: Gross value of repos and reverse repos outstanding from around 65 European institutions, in EUR tn. Includes sell-buy backs and buy-sell backs. Given that transactions between same counterparties are not netted out, some double counting is likely.
Sources: ICMA, ESMA.

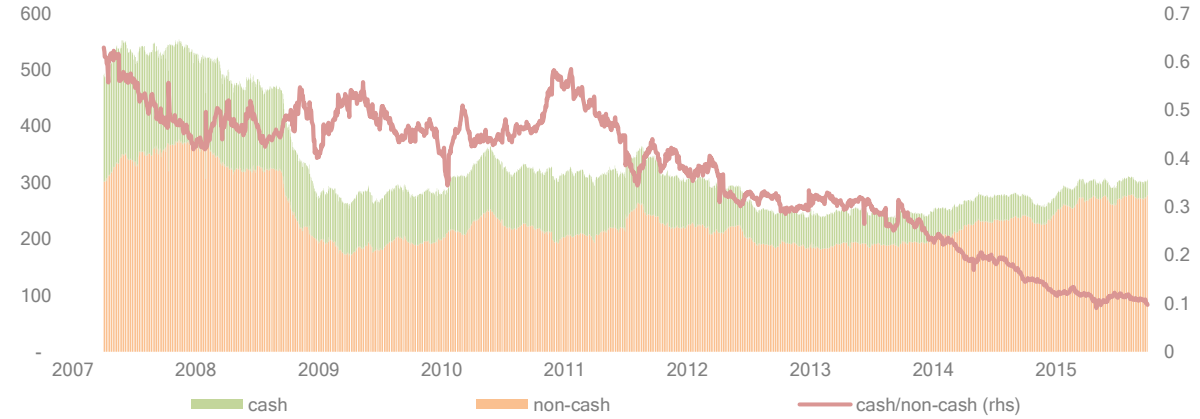
In a securities lending arrangement, the owner of a security lends it temporarily to a counterparty for a fee, against collateral in the form of other securities or cash. The borrower is obliged to return the securities to the lender either on demand (open transactions) or at the end of an agreed term (term transactions). The borrower is entitled to the economic benefits of the borrowed securities (i.e. receiving dividends or coupon payments) but the agreement with the lender obliges to "manufacture" payments back to the lender. When cash is used as collateral, the lender pays a rebate rate to the borrower that is lower than the prevailing fee, so that the lender can reinvest the cash collateral and make an additional return. In the trade negotiation phase, the parties take into account factors such as availability and demand for a particular security, collateral liquidity, expected dividends and the likelihood of the lender recalling the security early.

While the large majority of repos in Europe are done between banks (and through CCPs), securities lending markets bring together a wider variety of financial entities. On the lending side, the beneficial owners of the assets are mainly buy-side companies and institutional investors, such as mutual funds, insurance companies, pension funds and sovereign wealth funds. They lend securities in order to generate extra revenues, most of the time using agent lenders such as custodians, that manage large pool of securities and offer risk management and post-trading services (ESMA (2016)). Securities lending is also used for collateral

[8] http://www.icmagroup.org/Regulatory-Policy-and-Market-Practice/short-term-markets/Repo-Markets/

transformation, with e.g. mutual funds lending equities against government bond collateral. On the borrowing side mainly sit broker-dealers and hedge funds (through their prime broker) that want to borrow specific securities, mainly to short them, for collateral management purposes, for hedging or to avoid penalties from settlement fails.

Chart 2. EU Government bonds on loan, by type of collateral



Note: Outstanding value of European government bonds on loans against cash/non cash collateral, EUR billion. Ratio of cash/non-cash collateral on secondary axis.
Sources: Markit Securities Finance, ESMA.

As of the end of 2015, the value of EU securities on loan was around EUR 500bn composed of government bonds (EUR 300bn; Chart 2), corporate bonds (EUR 40bn) and equities (EUR 160bn), mostly on loan against non-cash collateral. In this paper, we use transactions collateralised with both cash and non-cash. Although cash-collateral transactions would arguably be more comparable to standard cash-for-securities repos, securities-against-securities loans are largely use to source specific assets, including high-quality collateral such as government bonds for so-called “collateral upgrades”. Activity in securities lending markets is therefore closely linked to the special repo market segment, and reflects developments in collateral markets.

Securities lending market activity peaked in 2007. As markets deteriorated in the course of 2008, there was a significant drop in the demand for securities due to deleveraging by funds (and broker-dealers), driven by the need to raise cash to meet investor redemptions and shrink their balance sheet. In parallel, the beneficial owners of the assets (asset managers, institutional investors and some public sector entities) became increasingly risk averse as the crisis unfolded and reduced their supply of securities by restricting the counterparties to which they were willing to lend securities. Lastly, temporary and prolonged bans on short selling in the EU may also have reduced demand for some securities. These dynamics caused the balance of EU securities on loan to fall by more than EUR 400bn in 2008, including 200bn for government bonds, EUR 50bn for corporate bonds and EUR 180bn for equities. Since the beginning of 2009, the balance of EU government bonds has been around EUR 270bn-300bn (of which more than 90% is collateralised with other securities).

Regulatory policy context

In the aftermath of the global financial crisis, global regulators set out several policy recommendations to address shadow banking risks specific to securities financing markets, which were perceived to have played a role in the crisis (FSB, 2013). The risks identified by the FSB (2012, 2013) were:

- **Securities lending cash collateral reinvestment**: The risks involved in cash collateral reinvestment stem from maturity and liquidity transformation, which if left unchecked can present negative externalities to firms beyond the lender in a stress event.
- **Facilitation of credit growth and build-up of leverage**: Securities lending markets contribute to the facilitation of credit growth and the build-up of leverage in the financial system allowing lenders to obtain relatively cheap and easy funding using their own assets.
- **Maturity transformation**: Securities lending transactions with open maturity are in vast majority. Open maturity transactions present a higher degree of risk than term maturity transactions: during a financial crisis, lenders can recall the securities lent at short notice and lenders may not be able to return them.
- **Interconnectedness**: The significant exposures built across the different types of financial institutions (e.g. custodians, asset managers, credit institutions and insurances) contribute to the formation of possible contagion channels. For agent lenders, who typically lend securities to other institutions on behalf of their clients and can reinvest the cash collateral in reverse repos with another entity, the resulting risks from a high degree of interconnectedness could become material (ESRB, 2014).

In particular, the FSB recommended that authorities collect granular data on securities financing transactions. The related EU Regulation on transparency of SFTs and of reuse[9] will improve the transparency of SFTs mainly in the following three ways. First, it requires that all transactions are reported to trade repositories, including the type of SFT, transacting counterparties, maturity, nature and quality of collateral, etc. This will allow supervisors to better understand the links between banks and non-banks, shed more light on some of their funding operations, and to monitor the exposures and risks associated with SFTs.

Second, the Regulation will improve transparency towards investors on the practices of investment funds engaged in SFTs and other equivalent financing structures by requiring detailed reporting on these operations, both in the regular reports of funds and in pre-investment documents[10]. This would lead to better-informed investment decisions by investors.

Finally, the Regulation will improve the transparency of the reuse[11] of collateral by setting minimum conditions to be met by the parties involved, including disclosure and written agreement. This would ensure that clients or counterparties give their consent before reuse can take place and that they make that decision based on clear information on the risks that it might entail.

A large part of these regulatory initiatives focus on the risks that SFTs may pose to financial stability, due to opacity of collateral reuse, collateral management practices and collateral valuation. For example, valuation is thought to increase system procyclicality: easier (tighter) conditions on secured lending transactions, e.g. changes in haircuts, tend to increase

[9] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R2365&from=EN

[10] The UCITS directive and subsequent ESMA guidelines had already taken steps in that direction.

[11] In the SFT Regulation, reuse also includes rehypothecation of collateral assets used e.g. in margin lending transactions, since these are economically equivalent to repos.

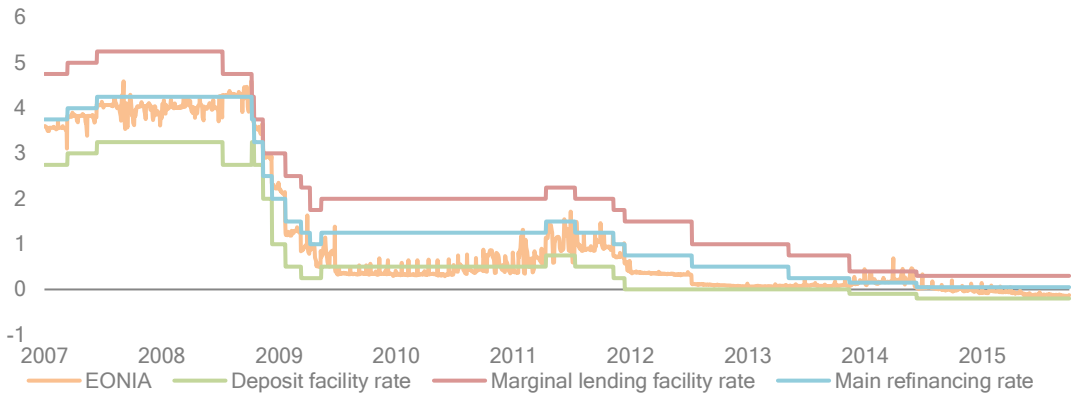
(decrease) leverage when market conditions are benign (deteriorating; BIS, 2010). In this framework, specialness should be of particular interest. Specialness contributes to increasing the price of the underlying collateral (Duffie, 1996), therefore understanding what the drivers of specialness are would help to single out individual factors or practices liable to increase procyclicality in the financial system.

Our paper also contributes to on-going policy discussions on the measurement of collateral reuse, with the FSB (2016a) proposing a set of possible measures and metrics. While most of the debate around collateral scarcity has so far focused on the demand and availability of collateral, measuring the intensity of collateral use and velocity is equally relevant from a financial stability perspective. Reuse may indeed help to address collateral shortages resulting from declines in collateral availability, but presents potential financial stability issues (FSB, 2016b). Such declines may be due to either increased counterparty credit risk, making investors less willing to lend securities, or to central bank asset purchases and the widening of eligible assets for pledging as collateral (Singh, 2016). Given the difficulty of measuring accurately the reuse of collateral, the FSB proposals included two approximate measures (direct and indirect). In the EU, the final measure will become part of the future SFTR reporting regime. We contribute to the debate by introducing a new measure of the reuse of collateral in SFT markets, which may also be useful for monitoring purposes until SFTR data becomes available.

Monetary policy context

The time period we analyse is particularly relevant from a policy perspective since it includes two important changes of monetary policy: the introduction of a negative interest rate on the ECB deposit facility and the launch of ECB quantitative easing. These unconventional monetary policy tools have a different impact on repo rates and specialness. In normal times, special repo rates can become negative due to exceptional demand or limited supply of specific securities. In a low interest rate environment, GC rates can also be negative, for example when yields on the collateral used are already very low or negative. With negative repo rates, the collateral buyer should in theory pay interest to the seller. On 11 June 2014, the ECB set its interest rate on the deposit facility at -0.10%, gradually leading the main unsecured overnight interbank rate (EONIA) below zero (Chart 3), which consequently drove short-term rates on secured transactions such as repos deeper into negative territory.

Chart 3: ECB key interest rates and EONIA



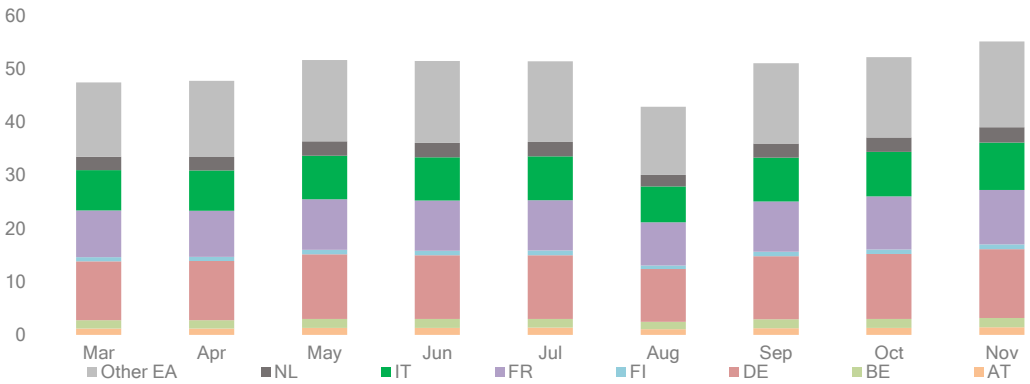
Note: ECB key interest rates and Euro Overnight Index Average (EONIA), in %.
Sources: European Central Bank, ESMA

In theory, since GC collateral provides the reference rate based on which special repo rates are negotiated, this should not have an impact on the scarcity premium, which is measured as the difference between GC and special rates. However, as special repo rates go deeper into negative territory, the incentive for the collateral seller to fail on its delivery increases. Under the General Master Repo Agreement, the standard contract governing repo markets, the repo rate agreed between parties is locked even in case of fail-to-deliver by the seller. With positive rates, when the seller fails to deliver, it still owes repo interest to the buyer, thereby creating a disincentive to fail[12].

With negative repo rates, however, the buyer pays interest on the money he is lending, therefore the seller could very well decide to fail, and still receive the repo interest. While the resulting incentives to fail are mitigated by penalties on settlement fails, these penalties could in theory be compensated by a high enough interest payment from buyer to seller, which depends on how far into negative territory repo rates are. Therefore, a seller might fail at no cost, or even make a profit from it. A punitive penalty regime, on the other hand, would drive market participants to borrow special collateral for a higher premium to avoid fails, and strengthen the relationship between specialness and short-selling activities or collateral reuse. As a consequence, we expect some of our variables of interest to respond differently before and after 11 June 2014.

With ECB quantitative easing, the main impact is on the available supply of collateral. On 22 January 2015, the ECB announced a public sector purchase programme, adding the purchase of government bonds to its existing private sector asset purchase programme[13] – in effect launching its own quantitative easing (QE) programme following similar actions previously taken by other large central banks (Federal Reserve, Bank of England, Bank of Japan). The combined asset purchases would amount to EUR 60bn per month until at least March 2017[14]. Between March and November 2015, purchases of government debt securities have averaged EUR 50bn (Chart 4).

Chart 4: ECB Monthly public sector asset purchases (2015)



Note: Monthly net purchases of public sector assets by thte European Central Bank, at book value., in EUR bn.
Sources: European Central Bank

[12] Industry representatives indicated that market participants sometimes set repo rates to zero in order to remove this incentive to fail. This helps to ensure the proper functioning of repo markets.

[13] In the analysed period the ECB private secor purchase programme was limited to asset backed securities and covered bonds.

[14] http://www.ecb.europa.eu/press/pr/date/2015/html/pr150122_1.en.html.

Corradin and Maddaloni (2016) show that the unannounced central bank purchases under the Securities Markets Programme (SMP) increased the scarcity premium of the bonds targeted by reducing their effective available supply on markets. The impact of SMP purchases also increased with the scarcity premium of bonds *before* the purchases took place, therefore heightening the probability of delivery fails. While similar effects can be expected from the ECB QE purchases, there are key differences to consider:

- Unlike the SMP, where purchases were unannounced, the ECB has clearly announced that bonds would be bought on a regular basis, therefore the overall impact of ECB purchases on Euro area government bond markets is anticipated and priced in.
- Although the ECB does not pre-announce which bonds it is going to buy, the relative size of purchases in each Euro area government bond market should reflect the related country's participation to ECB's capital; Therefore, the relative impact in terms of volumes in each market can be estimated. This is also different from the SMP where purchases concentrated on stressed bond markets only.
- Bonds that have been purchased by the ECB and the National Central Banks are then made available to market participants through a securities lending programme, which started on 2 April 2015, for a minimum fee of 40 basis points[15].

The implication of the first two points for our paper is that the ECB QE may result in bonds going more frequently on special, or with a larger scarcity premium. However, this effect may not be directly associated with specific ECB purchases (i.e. at the individual bond level) but rather with the overall impact of the programme. In addition, the ECB securities lending programme launched in April 2015 is expected to mitigate the impact of QE on collateral scarcity premia, although the existence of a minimum fee implies that specialness needs to be sufficiently high in order for these securities to be made available by the ECB to market participants.

Finally, the interaction between these unconventional monetary policy measures has consequences on the behaviour of market participants. A negative deposit rate acts as a disincentive for banks to place excess cash at the central bank. ECB QE purchases and refinancing operations contribute on the other hand to increasing the amount of money available to banks and circulating in the financial system. Together with prudential requirements encouraging banks to hold high-quality collateral, these policies lead to a situation where large amounts of money chase few assets, increasingly requiring financial institutions to optimise their collateral allocation and reuse high-quality collateral. While most of these assets are traded between banks (broker-dealers), some are exchanged with other market participants against lower quality assets through securities lending transactions (i.e. collateral transformation). In this context, the substitutability of securities lending transactions and special repos, as well as the reuse of collateral, are instrumental to the efficient allocation and fluidity of collateral in the system.

[15] The minimum fee was reduced to 30 basis points in April 2016. See the ECB website for more details on the securities lending programmes: https://www.ecb.europa.eu/mopo/implement/omt/lending/html/pspp-lending-ecb.en.html

3. Dataset and empirical model

In this section we describe the dataset used and the empirical model.

3.1 The dataset and variables description

Our dataset covers the period between 7 March 2013 and 21 September 2015. For repo data, we rely on ICAP RepoFundsRate (RFR) which includes information on repo transactions executed on BrokerTec or MTS, two of the three CCP-based electronic trading platforms for Euro repos.[16] We use a bond level database including daily observations of CCP-cleared repo transactions collateralised with government bonds of seven Euro area countries (Austria, Belgium, Finland, France, Germany, Italy, and the Netherlands), cumulatively representing almost 80% of 2015 Euro area general government debt. We enrich the data provided by ICAP with information regarding bonds' bid-ask spreads in cash markets, and time to maturity (from Thomson Reuters Eikon).

For each country, Table 1 reports the number of bonds, auctions and on-the run bonds[17] included in the sample, daily average values and time series standard deviations for specialness, repo trade volume, bid-ask spreads and time to maturity. More than 75% of the bonds in the sample belong to France, Italy and Germany (66% of Euro area government debt[18]). On average, France has 234 government bonds used in repo transactions on a daily basis, compared to 199 bonds for Italy and 163 for Germany. A lower number of government bonds is used in repo markets for Belgium, Netherlands, Austria and Finland, (respectively, 75, 64, 26 and 19 bonds). The average time to maturity of the bonds in the sample ranges from 8 to almost 13 years, broadly in line with the average maturity of government debt stocks in the Euro area[19]. The bid-ask spreads are normally used as a measure of market liquidity, capturing in particular the transaction cost dimension. On average, market liquidity in secondary sovereign debt markets is ample as reflected by bid-ask spreads ranging from 6 to 20 basis points.[20]

[16] Our data does not cover the entire universe of the Euro area repo market, but it captures almost 50% of the market. Indeed, according to the 2015 ECB money market survey, total secured lending was around EUR 450bn per day in 2Q15, compared to around EUR 200bn in RFR. Apart from BrokerTec and MTS, other platforms include for example Eurex Repo and MEFF.

[17] All the variables in the sample have daily frequency. It follows that for each day we determine if the bond is on the run or off the run, taking into accounts the differences between new issuances and reopenings.

[18] http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm.

[19] ECB Economic bulletin, various editions.

[20] For an ampler discussion of market liquidity and metrics in EU sovereign bond markets, see "EU sovereign bond market liquidity" article in ESMA (2017).

Table 1: Repo and government bond markets in Euro area countries

Country	Number of bonds	Number of on-the-run bonds	Number of auctions	Daily averages							
				Specialness		Repo trade size		Bid-ask spreads		Time to maturity	
				Mean	SD	Mean	SD	Mean	SD	Mean	SD
Austria	26	15	45	2.2	3.2	218.7	134.9	20.8	19.2	12.91	13.14
Belgium	75	26	57	2.9	3.8	261.2	198.4	11.6	10.9	9.00	10.70
Finland	19	16	6	2.6	3.9	202.2	125.1	9.1	6.2	10.24	8.62
France	234	54	205	2.1	2.6	361.9	387.8	14.0	16.9	10.21	13.00
Germany	163	46	79	3.1	4.1	629.9	606.4	13.6	16.2	8.77	10.78
Italy	199	35	223	2.2	3.9	604.5	442.4	10.1	12.0	8.15	9.73
Netherlands	64	27	34	2.8	3.7	336.2	238.7	6.6	7.7	9.04	10.58

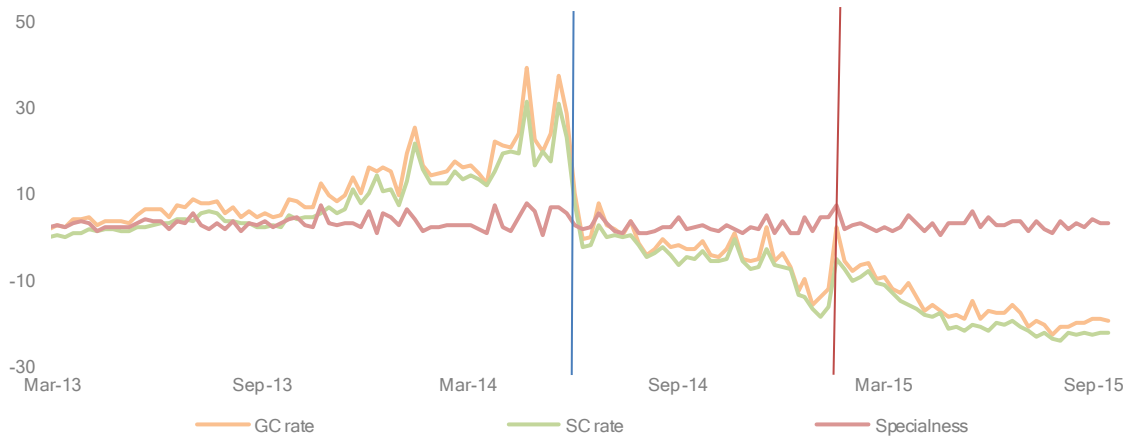
Note: Specialness and Bid-ask spreads in basis points. Repo trade volume is in million of securities. Time to maturity is measured in number of years.
Sources: ICAP RFR, Brokertec, MTS, ESMA.

The percentage of on-the-run bonds is heterogeneous in the sample, going from 18% in Italy to 84% in Finland, the highest percentages being in countries with the lowest number of bonds.[21] As already mentioned in section 2.1, the literature has shown the impact of the auction cycle on specialness in US repo markets. We investigate whether the existence of a similar relationship in the Euro area is supported by empirical evidence. The number of cash market auctions in the sample amounts to 649 (first issues plus reopenings). Auctions are very heterogeneously distributed across countries, but proportional to the corresponding amount of government bonds, ranging from 6 for Finland to 223 for Italy.

We define specialness as the difference between the related GC repo rate in country *j* and the volume-weighted average repo rate (VWAR) for bond *i* at time *t*[22](chart 5):

$$Specialness_{ijt} = GC_{it} - VWAR_{ijt}$$

Chart 5: Evolution of specialness in Euro area repo markets



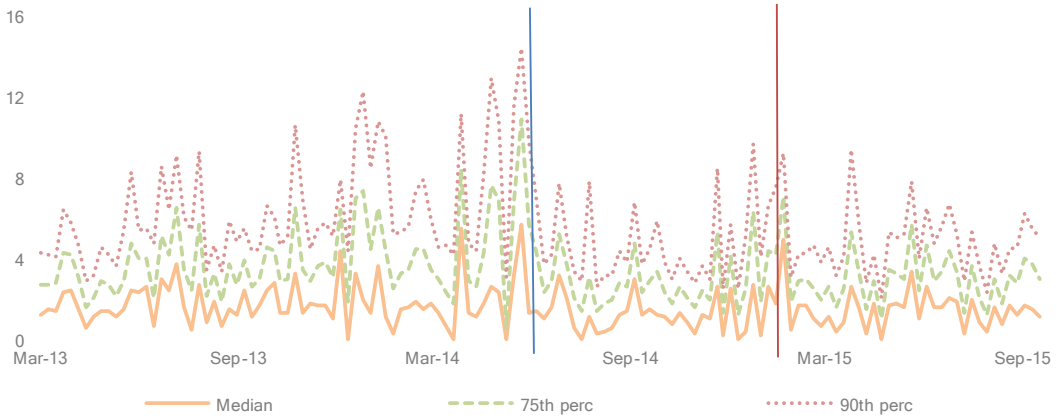
Note: Average specialness, GC and SC rates (country means). Weekly data in basis points. The vertical lines indicate, respectively, the introduction of negative deposit rates on 11 June 2014 (blue) and the launch of ECB QE on 9 March 2015 (red).
Sources: RepoFunds Rate (BrokerTec, MTS, ICAP), ESMA.

[21] Annex A shows descriptive statistics of the variables reported in Table 1 and 2, distinguishing between the on-the-run and off-the-run bond samples.

[22] For each ISIN, the following variables are available in RFR: Total number of repo trade; Maximum transacted repo rate; Minimum transacted repo rate; Volume-weighted average repo rate; Total transacted volume.

During crisis periods more bonds tend to become special and investors may pay larger premia to obtain some specific securities. At the same time, very special bonds – the upper tail of the distribution – are particularly sensitive to changes in market demand, especially in periods of market stress (Corradin and Maddaloni (2016)). Therefore, in crisis periods, specialness distribution tends to become more dispersed. Looking at Chart 6, which provides a graphical illustration of the distribution of specialness in our data, this particular feature is hardly predominant since we analyse a time period mainly characterised by very low interest rates and reduced volatility.[23]

Chart 6: Distribution of specialness in Euro area repo markets



Note: Median, 75th and 90th percentile of specialness, defined as the difference between GC and SC rate. The vertical lines indicate, respectively, the introduction of negative deposit rates on 11 June 2014; Red bar corresponds to the beginning of ECB quantitative easing on 9 March 2015. Weekly data.
Sources: RepoFunds Rate (BrokerTec, MTS, ICAP), ESMA.

For each day and bond, we link the data on repo market from RFR with data on securities lending market from Markit Securities Finance[24]. Table 2 presents standard descriptive statistics for securities lending variables: broker-to-broker activity, utilisation rate, lendable quantity, borrower concentration, and average tenure.

Table 2: Government bond lending market in Euro area countries

Country	Daily averages									
	Broker-to-broker activity		Utilisation rate		Lendable quantity		Borrower concentration		Average tenure	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Austria	7.0	9.6	36.70	21.90	646.9	338.8	0.31	0.19	124.05	95.63
Belgium	45.1	344.9	26.95	23.28	583.9	410.5	0.33	0.27	140.19	122.72
Finland	1.5	3.8	40.61	17.92	490.4	190.8	0.37	0.18	148.81	126.79
France	13.2	40.7	35.06	27.02	1,005.9	846.1	0.34	0.29	132.71	98.63
Germany	107.1	813.5	48.92	27.90	1,459.0	1,335.4	0.28	0.26	119.52	90.25
Italy	0.9	6.3	7.99	12.39	489.1	413.4	0.44	0.38	96.91	107.30
Netherlands	5.1	7.2	35.41	20.21	1,427.5	870.4	0.27	0.25	157.28	128.46

Note: Broker-to-broker activity and Utilisation rate in % of Lendable quantity. Lendable quantity in million of securities. Borrower concentration takes a value comprised between 0 and 1 measuring the distribution of borrower demand. Average tenure in number of days.
Sources: Markit Securities Finance, ESMA.

[23] For updates of the repo specialness indicator, see the quarterly ESMA Risk Dashboard (RD) available on ESMA's website: https://www.esma.europa.eu/market-analysis/financial-stability. A chart

[24] Markit Securities Finance collects securities lending information daily from 125 large custodians and 32 prime brokers, covering more than 85% of the global securities lending market.

Both broker-to-broker activity and utilisation rate are in % of lendable quantity. Lendable quantity, which is the quantity of securities in securities lending programmes, ranges in our sample from 485 million government bonds for Italy to 1.5 billion government bonds for Germany.

Broker-to-broker activity aims to capture government bond lending activity between brokers. We define broker-to-broker activity as the ratio of broker quantity on loan to lendable quantity[25]. Broker quantity on loan is calculated as the difference between total quantity on loan and lender quantity on loan. Lender quantity on loan is the traditional securities lending channel, whereby brokers borrow assets from lenders that are mainly asset managers and institutional investors (e.g. pension funds, mutual funds, insurance companies, sovereign wealth funds and central banks), lending securities on a principal basis or through agent lenders (e.g. custodian banks).

We use broker-to-broker activity as a proxy for reuse of collateral. There are several reasons to support this. First, lenders do not reuse non-cash collateral. This is the case not only for agent lenders[26], but also for buy-side investors that lend on a principal basis (such as UCITS and asset managers) and are prevented by regulation to reuse collateral. Second, brokers – who do not face similar restrictions in terms of collateral reuse – lend securities almost exclusively against non-cash collateral. In addition, both the lendable quantity of government bonds and the lender quantity of bonds on loan (i.e. excluding broker quantity on loan) are broadly stable over time. Therefore, peaks in broker-to-broker activity reflect either high demand for securities, limited collateral availability, or a combination of both. All other things equal, this suggests that the most likely adjustment variable is collateral reuse by brokers. This is also supported by recent discussions about European bank inventories, although there is currently no hard evidence to substantiate the claim that these inventories have declined (ESRB, 2016).

Although there is likely some noise around this definition (e.g. brokers may lend their own securities and not only reuse collateral), we believe that this is a reasonable proxy[27]. While most of SFT market activity in government bonds between brokers is concentrated in repo markets, the large volumes of government bonds on loan against non-cash collateral, together with the strong similarity with special repos (as described above) and the large substitutability of these two types of SFTs, suggest that our collateral reuse proxy should reflect to a large extent collateral reuse dynamics on repo markets.[28]

Broker-to-broker activity in Germany and Belgium is equal respectively to 107% and 45%, much higher than in the other countries in the sample (which range from 1% to 13%), signalling

[25] Total quantity on loan includes securities loans from both brokers and lenders.

[26] Following the bankruptcy of Lehman Brothers, some agent lenders were unable to locate their clients' assets, which had been reused several times as collateral in other transactions, and had to offer indemnifications to compensate their clients.

[27] In particular, since broker quantity on loan is divided by lendable quantity, increases in broker quantity on loan that only reflect increases in lendable quantities are neutral. Moreover, brokers tend to pool together their own assets and the collateral received, therefore the distinction between the two is usually not possible (see responses to SFTR Discussion Paper on ESMA's website).

[28] While this measure reflects changes in the level of collateral reused, the nominal value captures only the securities lending segment of collateral markets. Therefore, the nominal value itself should not be taken as an accurate estimate of the volume of collateral reused.

that reuse of collateral seems to be more frequent in the case of bonds issued by these two countries. A broker-to-broker activity ratio above 100 implies that bonds in our sample are reused on average more than once, and the high standard deviations in Germany and Belgium show that some of the bonds are in practice reused multiple times.

Utilisation rate is defined as the ratio of lender quantity on loan to lendable quantity. Utilisation rate is used as a proxy for short-selling activities, as is done elsewhere in the literature[29]. Indeed, borrowing securities with an open term allows short sellers to deliver the securities they are betting against[30]. The securities are then returned to the lender when the short position is closed. The utilisation rates take values that are mainly comprised between 25% and 40% across countries, with the exception of Italy where the rate is around 8%.[31]

Borrower concentration is a Herfindahl-Hirschman index that takes a value comprised between 0 and 1 measuring the distribution of borrower demand in securities lending markets. A very small number indicates a large number of borrowers with low borrowed values and 1 indicates a single borrower with all the broker demand. Borrower concentration is rather homogeneous among countries in the sample, likely reflecting the cross-border nature of Euro area SFT markets, ranging from 0.27 in Netherlands to 0.44 in Italy.

Average tenure is the average length of government bond lending transactions in days, weighted by loan value. The average tenure for government bond lending transactions included in the sample ranges from 3 to 4 months, without major differences across countries.

3.2 The empirical model

We first employ panel data analysis to study how collateral reuse, proxied by broker-to-broker activity, and short selling, proxied by utilisation rate, affect the specialness of a specific bond in the repo market. We use variables related to government bond lending transactions and bond-specific characteristics as controls. Our baseline model is the following:

$$Specialness_{it} = \alpha + \beta\,(broker\ to\ broker\ activity_{it}) + \gamma\,(utilisation\ rate_{it}) + \delta(bond\ specific\ controls_{it}) + z\,(government\ bond\ lending\ controls_{it}) + \varepsilon_{it}$$

We expect a negative relation between broker-to-broker activity and specialness: Greater reuse of collateral increases the supply of securities, in addition to the traditional securities lending chain (brokers borrowing securities from lenders). This decreases the probability that these securities are on special and reduces the scarcity premium.

In line with the existing literature we expect a positive relation between utilisation rate (short selling proxy) and specialness. Indeed, if a trader sells short a bond in the cash market, he may either enter a simultaneous reverse repo transaction and borrow the bond to cover the

[29] See for example Engelberg et al. (2015), Luiz et al. (2014) and Aggarwal et al. (2016).

[30] For European government bonds, around 80% of lender quantity on loan is open term.

[31] It should be noted that the nominal value of the utilisation rate is not by itself an indication of the level of short-selling activity taking place, as it also reflects the lendable quantity of securities. Short-term increases in the utilisation rate, on the other hand, reflect increased short-selling activity.

short position and settle the trade (see Duffie, 1996) or borrow it in the securities lending market.

Borrower concentration is used to describe the structure of securities lending markets. A lower number of borrowers with high borrowed volumes – i.e. higher borrower concentration – is expected to be related to lower specialness. All other things equal, borrowers with high market power can indeed be expected to obtain more favourable transaction terms, i.e. to pay a lower price for the securities they borrow.

Average tenure is used to measure the average length of government bond lending transactions. We expect that specialness is greater for bonds used in short-term trades than for bonds used in long-term ones. This is owing mainly to the relatively short period of times that bonds remain on the run. The size of the repo transaction is also introduced in the regression to control for demand dynamics.

We use the time-to-maturity and bid-ask spreads of bonds traded in cash markets as proxies for the liquidity of that specific bond. Accordingly, the correlation between these two variables is high (0.88). Generally, for comparable maturities, bonds that have been issued earlier tend to have lower liquidity, in part because it is likely that significant amounts of these bonds are held by buy-and-hold investors and therefore not readily available for trading in the market (Corradin and Maddaloni, 2016).[32]

We also include four dummy variables equal to 1 when the bond is respectively on the run with 1-year maturity, on the run with 5-year maturity, on the run with 7-year maturity, or on the run with 10-year maturity, and 0 otherwise. We use the above dummies to investigate if among the on-the-run bonds some maturities tend to have a higher degree of specialness than others. Moreover, we add a dummy variable equal to 1 the first day a bond is off the run and 0 otherwise: we expect a negative relation between this dummy and specialness, in line with previous literature showing that on-the-run bonds are typically more special due to their liquidity premium (Duffie, 1996; Krishnamurthy, 2002). Moreover, we expect our main variables of interest (short-selling activity and broker-to-broker activity) to have greater statistical significance in the on-the-run bond sample.

We finally introduce a dummy variable for the announcement of a new auction, and another one for the new auction, in order to take into account in our framework the auction cycle, whose relevance has also been introduced in Duffie (1996).

Broker-to-broker activity, utilisation rate, average size of repo transactions and borrower concentration are included in the estimates with a lag to address potential endogeneity issues.

As robustness check we run Tobit analysis to address potential issues related to the fact that our dependent variable – specialness – is zero for a non-irrelevant number of observations in the sample.

4. The empirical results

We analyse the drivers of specialness in three different sub-periods: between 7 March 2013 and 10 June 2014 (date of the introduction of negative interest rates on the ECB deposit

[32] We ran all the regressions with time-to-maturity measured in months and results did not change. Results are available on request.

facility); between 11 June 2014 and 8 March 2015 (the ECB quantitative easing start) [33]; between 9 March 2015 and 21 September 2015.[34] We run our regressions separately for the three sub-periods since, as explained in section 2, we expect our variables of interest to respond differently before and after the changes of monetary policy. For each sub-period we run separate regression for the whole sample, for the on-the-run sample, and for the off-the run sample.

Table B1, B2 and B3 in Annex B shows the results for the whole sample, on-the-run sample and off-the-run sample, respectively for:

- The first sub-period, i.e. before the introduction of negative interest rates on deposits (Table B1);
- The second sub-period, after the introduction of negative deposit rates and before the start of quantitative easing (Table B2);
- The third sub-period, after the beginning of QE (Table B3).

We obtain quite strong results supporting our hypothesis that collateral reuse consistently contributes to decreasing the scarcity premium of a specific bond, as reflected by the negative and mostly statistically significant relationship between broker-to-broker activity and specialness, across the different samples and sub-periods. As expected, and consistently with the existing literature, short selling activity has a positive and significant relationship with specialness across different samples and sub-periods. However, the economic effect is small: on average, a 1 percentage-point increase in the utilisation rate of a bond leads to a 0.01 basis point increase in scarcity premium.

The results are very similar for the first and second sub-periods, i.e. before the launch of ECB QE, highlighting that the introduction of a negative deposit rate has not had a major impact on collateral scarcity premia in repo markets. In other words, the existing penalty regime on settlement fails does not seem to have increased collateral scarcity in the context of negative interest rates, although there were possibly other forces at play. In contrast, the generally lower statistical significance of the variables in our model during the third sub-period highlights the more significant impact of ECB quantitative easing and securities lending programmes. While this seems to confirm the *ex-ante* expectation that the ECB securities lending programme addresses any collateral scarcity created by QE purchases, a closer look at the results reveals some important differences in the estimated coefficients for the on-the-run and off-the-run bond samples.

First, the statistical relationship between specialness and collateral reuse is consistently stronger for on-the-run bonds. This reflects either the fact that on-the-run bonds are typically more special due to their liquidity premium, as in Duffie (1996), or the preference of brokers for very liquid securities, as in Graveline and McBrady (2011). Second, collateral reuse remains statistically significant at the 1% level for on-the-run bonds in the third sub-period, and the coefficient is much larger than for the previous sub-periods: a 1 percentage-point increase in reuse leads to a 0.5 basis point decline in scarcity premium (compared to average

[33] ECB QE focuses on bonds that are usually liquid with a high degree of interdealer activity, and therefore such bonds tend to go more frequently on special.

[34] For the analysis of the events we do not consider the launch of the ECB QE (22 January 2015) but the actual start of the programme on 9 March 2015, although both dates were tested. See https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html for more details about QE.

premia of 2.5 basis points; Table A1a). This likely reflects the central role of brokers borrowing securities from the ECB and reusing them through other transactions, to efficiently allocate high-quality collateral where it is needed the most.[35]

Regarding off-the-run bonds, the generally lower statistical significance of these two explanatory variables likely reflects the lower relevance of these bonds to brokers in the context of short-selling activities and collateral reuse. Supporting this view, the daily average repo trading volume of on-the-run bonds increased 6.5% between the first and third sub-period, while it declined 7.7% for off-the-run bonds, although the ECB can purchase both types of securities. More strikingly, daily average broker-to-broker activity rose 89% compared to 38%, respectively, for on-the-run and off-the-run bonds, over the same time frame.

Turning to the other explanatory variables, average size of repo transaction is negatively but not always significantly related to specialness, meaning that larger transactions volumes, compared to the outstanding amounts, sometimes decrease specialness. This result is in line with borrower concentration which also has a negative effect on specialness, although with greater statistical significance (for off-the-run bonds): a lower number of borrowers trading larger volumes is related to lower specialness. However, the absence of empirical relationship between specialness and borrower concentration for on-the-run bonds differs from the model of Vayanos and Weill (2008).

Regarding time-related variables, average tenure has an overall negative and statistically significant relation to specialness, confirming that specialness tends to be greater for bonds used in short-term trades than for bonds used in long-term ones. This may be linked to the short amount of time that bonds remain on-the-run, due to regular auctions, naturally limiting the length of transactions using on-the-run bond collateral. In contrast, the bond time-to-maturity coefficient is only irregularly statistically significant (positive). This is in line with previous findings that evidenced the absence of clear relationship between repo rates and the term structure.

Lastly, we turn to variables that relate to bond liquidity. Regarding the auction cycle, the announcement of a new issuance is statistically significant and positively related to specialness, while the occurrence of a new auction negatively affects specialness. This result is consistent with Duffie (1996) who showed that traders take short positions in advance of the auction in order to take advantage of the liquidity of on-the-run bonds. These short positions are then unwound on auction day. In contrast, higher secondary market liquidity of the sovereign bond used as collateral in repo transactions measured by lower bid-ask spreads does not seem to be associated with higher specialness, as indicated by the poor statistical significance across different regressions.

To address the concern related to having values of the specialness equal to zero or very close to it (suggesting that specialness is a truncated or limited dependent variable), we run the analysis also using Tobit panel regressions. Our main results related to the relation of short

[35] The ECB website indicates indeed that the arrangements are “aimed at primary dealers of Euro area sovereign bonds and at other institutions with market making commitments”. See: http://www.ecb.europa.eu/mopo/implement/omt/lending/html/pspp-lending-ecb.en.html).

selling activities and collateral reuse with specialness are confirmed, although the levels of significance are not as strong (Tables B4-B7).[36]

5. The dynamics of specialness around changes in monetary policy

To narrow down our investigation into the dynamics of specialness around changes in monetary policy, we focus our econometric exercise on the five days before and after each of the following events:

- Introduction of a negative deposit rate on 11 June 2014;
- Beginning of quantitative easing on 9 March 2015;
- Introduction of the ECB Securities Lending Programme on 2 April 2015.[37]

As of 2 April 2015, the securities purchased under QE were made available for lending, either bilaterally, with the intermediation of agent lenders, or through central securities depositories. The aim of securities lending is to support bond and repo market liquidity without unduly curtailing normal repo market activity.[38] The ECB Programme primarily targets market makers such as large broker-dealers, which makes it relevant from a collateral reuse perspective.

We use the following specification to analyse the stability of the relation of collateral reuse and short selling activity with specialness around monetary policy changes.[39]. The new specification is:

$$\begin{aligned} Specialness_{it} = {} & \alpha + \beta_1(broker\ to\ broker\ activity_{it}) \\ & + \beta_2(broker\ to\ broker\ activity_{it})I(post) + \gamma_1\,(utilisation\ rate_{it}) \\ & + \gamma_2(utilisation\ rate_{it})I(post) + \delta(bond\ specific\ controls_{it}) \\ & + z\,(government\ bond\ lending\ controls_{it}) + \eta I(post) + \varepsilon_{it} \end{aligned}$$

where *I(post)* is a dummy equal to one after the event. In addition, we interact the *I(post)* dummy variable with broker-to-broker activity and utilisation rate to assess the specific impact of the monetary policy measures on the relation of short-selling and collateral reuse with specialness.

In tables C1 to C3 in Annex C, we report the results around these three events for the full sample, for the on-the-run sample and for the off-the run sample. Results on the relation of specialness with collateral reuse and short-selling activities are confirmed by the statistically

[36] The relation of market liquidity with specialness turns negative with Tobit estimates, i.e. bid-ask spreads are positively related to specialness. One potential explanation is related to the lower availability of a single bond in the cash market increasing the demand for financing in the repo market. Corradin and Maddaloni (2016) find bid-ask spreads to be non-statistically significant for the Italian repo market, which they attribute to other variables capturing the liquidity effects.

[37] We performed the same analysis with a ten-day window before and after the event. Although the results were stronger for several variables, the proximity of two events (the Securities Lending Programme was announced 28 days after the launch of ECB QE) led us to keep only the results using a five-day window in order to avoid biases. In addition, we also investigated the further decrease of the ECB deposit rate on 10 September 2014. The results of these regressions are available on request.

[38] https://www.ecb.europa.eu/mopo/implement/omt/lending/html/index.en.html

[39] This specification differs from the one in section 3.2 because it does not include the *Announcement, Auction and First day off* dummy variables for which there were only a few observations in the time windows around the events. The dummy variables 1y on-the-run, 5y on-the-run, 7y on-the-run and 10y on-the-run are substituted by a single on-the-run dummy variable. Nevertheless, as a robustness check, we ran the regressions for all events including all these variables, obtaining the same results. The results of these regressions are available on request.

significant coefficients before the events concerned in the whole sample (with the exception of the ECB securities lending programme event; Table C1).

The introduction of a negative deposit rate is associated with lower specialness of bonds in the sample, as shown by the negative coefficient of the *I(post)* dummy variable. In contrast, the launch of QE is followed by higher specialness, highlighting the impact of ECB government bond purchases on collateral scarcity, and resulting in greater premia on special collateral, albeit of less than a basis point. Higher premia from relative collateral scarcity appear subsequently offset by the beginning of the ECB Securities Lending Programme, with the estimated coefficient of the *I(post)* dummy variable turning positive again, and much larger than with QE. The *On the run* variable is only statistically significant around the introduction of a negative deposit rate.

Regarding the interaction variables, in the full sample (Table C1) broker-to-broker activity is not statistically significant when interacted with *I(Post)*, suggesting that the relation between collateral reuse and specialness is not impacted by policy changes. In contrast, the negative (and statistically significant) coefficient for the utilisation rate around the introduction of the negative deposit rate and QE highlight that the impact of short-selling activities on collateral scarcity premia is reduced following these policy changes, while the ECB Securities Lending Programme increases the effect from short-selling activities. These results are confirmed mainly for the off-the-run bond sample. This differs from the regressions presented in section 4 in which the statistical relationship between specialness and the main variables of interest was generally stronger for the on-the-run sample. This specific feature could be related to the short time window around the events.

6. Conclusions

This paper analyses the drivers of the cost of obtaining high-quality collateral, proxied by specialness of government bond repos, in seven Euro area countries, between March 2013 and September 2015. Without easy access to high-quality collateral, market participants would find it more costly to trade, with a negative impact on financial stability through reduced market liquidity, and on the real economy through increased frictions in bond market financing for non-financial corporations and reduced bank lending due to higher funding costs.

Building on the existing literature, we investigate some of the findings pertaining to US repo markets in a European context, where the structure of repo markets is different. Our results confirm the importance of liquidity for specialness, as reflected in the auction cycle and the stronger statistical relationship for on-the-run bonds. In contrast, the cash market liquidity of the underlying bonds used as collateral, measured by bid-ask spreads, does not appear to be relevant in the context of specialness.

The empirical results also confirm that the cost of obtaining high-quality collateral increases with demand pressures in the cash market (short selling activities), even in calm financial conditions. In bear market conditions – when good collateral is needed the most – this could lead to tensions in some asset market segments. For this purpose, the distribution of repo specialness is a useful risk indicator to detect the rise of financial stress in European SFT markets, either from increased short-selling activity or from limited collateral availability.

The new measure of collateral reuse introduced in this paper shows that reuse can play an important role in reducing collateral scarcity premia, by addressing potential shortages

resulting from demand pressures or supply restrictions. However, it requires transparency and monitoring due to the potential financial stability risks associated with this practice. Our analysis contributes to the on-going discussions on the measurement of collateral reuse by proposing a new indicator for monitoring purposes, based on already existing data. This also suggests a possible role to be explored for collateral reuse as a countercyclical instrument, which would aim to encourage reuse during stress periods, and constrain it during the build-up phase of leverage cycles.

Finally, the period analysed in this paper includes the beginning of ECB quantitative easing in March 2015 and of the ECB securities lending programme the following month. We find that ECB quantitative easing has a statistically significant, albeit limited, impact on sovereign collateral scarcity premia. However, this impact is soon offset by the beginning of the ECB Securities Lending Programme a month later.

The availability of new data on SFTs coming from the EU Regulation on the transparency of securities financing transactions will significantly improve the transparency of repo markets, securities lending, and more broadly collateral reuse practices in European SFT markets, and allow for further research in this area.

References

Aggarwal, R., J. Bai, and L. Laeven (2016) “The Role of the Government Bond Lending Market in Collateral Transformation” (November 4, 2016): https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2692251

BIS (2010) “The role of margin requirements and haircuts in procyclicality”, Committee on the Global Financial System Paper No. 36, March 2010.

Boissel, C. F., E. O. Derrien and D. Thesmar (2015) “Systemic risk in clearing houses: Evidence from the European repo market”, ESRB working paper No.10, May 2016.

Bottazzi, J.-M., J. Luque and M. Pascoa (2012) “Securities market theory: Possession, repo and rehypothecation”, Journal of Economic theory, Vol. 147, Issue 2, pages 477-500.

Buraschi, A. and D. Menini (2002) “Liquidity risk and specialness”, Journal of Financial Economics, Vol. 64, issue 2, pages 243-284.

Corradin, S. and A. Maddaloni (2015) “The importance of being special: repo markets during the crisis”, http://www.greta.it/sovereign/sovereign2/papers/02_Corradin.pdf.

D’Amico, S., R. Fan and Y. Kitsul (2014) “The scarcity value of Treasury collateral: Repo market effects of security-specific supply and demand factors” (FEDS working paper n.60).

Duffie, D. (1996) “Special repo rates” Journal of Finance 51, 493-526.

Dufour, A. and F. Skinner (2005) “Degrees of specialness: an empirical analysis of the Italian BTP repo market”.

ECB (2015) “Euro money market study 2015”.

Engelberg, J., A. Reed and M. Ringgenberg (2015) “Short selling risk”.

Eren, E. (2014) “Intermediary funding liquidity and rehypothecation as a determinant of repo haircuts and interest rates”, working paper, Stanford University.

ESMA (2016) “Report on securities financing transactions and leverage in the EU”.

ESMA (2017) “Report on Trends, Risks and Vulnerabilities”, No.1, 2017.

ESRB (2014) “Securities financing transactions and the (re)use of collateral in Europe – An analysis of the first data collection conducted by the ESRB from a sample of European banks and agent lenders”, Occasional paper No. 6.

ESRB (2016) “Market liquidity and market making”: https://www.esrb.europa.eu/pub/pdf/reports/20161005_market_liquidity_market_making.en.pdf.

FSB (2012) “Report on Securities Lending and Repos: Market Overview and Financial Stability Issues”.

FSB (2013) “Strengthening Oversight and Regulation of Shadow Banking. Policy Framework for addressing Shadow Banking Risks in Securities Lending and Repos”.

FSB (2016a) “Transforming shadow banking into resilient market-based finance. Possible measures of non-cash collateral re-use”.

FSB (2016b) “Transforming shadow banking into resilient market-based finance. Re-hypothecation and collateral re-use: Potential financial stability issues, market evolution and regulatory approaches”.

Fuhrer, L. M., B. Guggenheim and S. Schumacher (2015) “Re-use of collateral in the repo market”, Swiss National Bank Working Paper No.2, 2015.

Graveline, J. J. and M. R. McBrady (2011) “Who Makes On-The-Run Treasuries Special?”, Journal of Financial Intermediation, 20(4), 620–632.

Gorton, G. and A. Metrick (2012) "Securitized banking and the run on repo," Journal of Financial Economics, 104(3), 425-451.

Hordahl, P. and M. King (2008) “Developments in repo markets during the financial turmoil”, BIS Quarterly Review.

Infante, S. (2015) “Liquidity Windfalls: The Consequences of Repo Rehypothecation”, Finance and Economics Discussion Series No. 02.

Krishnamurthy, A. (2002) “The Bond/Old-Bond Spread”, Journal of Financial Economics. November 2002, Vol. 66, Issue 2-3, 463-506.

Longstaff, F. (2000) “The Term Structure of Very Short-Term Rates: New Evidence for the Expectations Hypothesis”, Journal of Financial Economics 58, 397-415.

Luiz, F., R. Kraussi and P. Stork (2014) “The European short sale ban: an option market perspective”.

Mancini, L., A. Ranaldo and J. Wrampelmeyer (2015) “The Euro Interbank Repo Market”, Review of Financial Studies, Vol. 29, Issue 7, 1747-1779.

Moulton, P. (2004) “Relative repo specialness in US repo markets”, Journal of Fixed Income, Vol. 14, No. 1, 40-47.

Singh, M. (2016) “Collateral and Financial Plumbing”, Riskbooks.

Vayanos, D. and P.O. Weill (2008) “A search-based theory of the on-the-run phenomenon”. The Journal of Finance Vol. 63, No. 3, 1361-1398

Annex A: Descriptive statistics

Repo and government bond markets in Euro area countries

Table A1a: Specialness

	Full sample	On the run	Off the run
Mean	2.497	2.625	2.450
Median	1.400	1.600	1.400
Standard deviation	3.666	3.729	3.641

Table A1b: Repo trade size

	Full sample	On the run	Off the run
Mean	467.6	486.5	460.7
Median	342.0	338.0	344.0
Standard deviation	454.8	494.3	439.2

Table A1c: Bid-ask spread

	Full sample	On the run	Off the run
Mean	11.92	13.58	11.21
Median	6.99	8.15	6.33
Standard deviation	14.29	14.65	14.08

Table A1d: Time to maturity

	Full sample	On the run	Off the run
Mean	9.2	12.9	7.9
Median	5.4	9.3	4.1
Standard deviation	11.2	12.5	10.3

Sources: ICAP RepoFunds Rate, BrokerTec, MTS, Bloomberg, ESMA.
Note: Specialness and bid-ask spread in basis points. Repo trade size in million euros. Time to maturity in years.

Government bond lending markets in Euro area countries

Table A2a: Broker-to-broker activity

	Full sample	On the run	Off the run
Mean	31.9	25.6	34.2
Median	0.6	1.7	0.18
Standard deviation	398.4	277.4	434.6

Table A2b: Utilisation rate

	Full sample	On the run	Off the run
Mean	29.6	30.8	29.1
Median	23.0	26.6	20.9
Standard deviation	27.2	24.3	28.1

Table A2c: Lendable quantity

	Full sample	On the run	Off the run
Mean	909.3	994.9	878.1
Median	655.3	737.7	613.6
Standard deviation	920.7	868.1	937.2

Table A2d: Borrower concentration

	Full sample	On the run	Off the run
Mean	0.351	0.324	0.361
Median	0.250	0.244	0.253
Standard deviation	0.310	0.262	0.325

Table A2e: Average tenure

	Full sample	On the run	Off the run
Mean	133	130	134
Median	111	111	111
Standard deviation	103	96	106

Sources: Markit Securities Finance, ESMA.
Note: Broker-to-broker activity is defined as the ratio of the difference between quantity on loan and lender quantity on loan to lendable quantity. Lendable quantity and quantities on loan are in millions of securities. Broker-to broker activity and utilisation rates are expressed as % of lendable quantity. Average tenure in days.

Annex B: OLS panel and Tobit estimates

Table B1: OLS panel estimates, first sub-period (7 March 2013 to 10 June 2014): Full sample, on-the-run sample and off-the-run sample

	Full sample	On the run	Off the run
Broker-to-broker activity	-0.069***	-0.050***	-0.070**
	(0.019)	(0.015)	(0.028)
Utilisation rate	0.017***	0.019***	0.014***
	(0.004)	(0.006)	(0.004)
Average size of repo transaction	0.708	-3.613	1.728
	(1.796)	(2.552)	(2.187)
Borrower concentration	-0.462**	-0.106	-0.715***
	(0.222)	(0.288)	(0.271)
Average tenure	-0.003***	-0.004***	-0.002**
	(0.001)	(0.001)	(0.001)
Time-to-maturity	0.275	0.109	0.611
	(0.356)	(0.363)	(1.987)
Bid-ask spread	-0.008	-0.024*	0.001
	(0.010)	(0.014)	(0.011)
Announcement	0.977***	0.996***	
	(0.274)	(0.338)	
Auction	-1.064***	-0.939***	
	(0.197)	(0.209)	
First day off	0.437		
	(0.303)		
1y on-the-run	0.201	-0.138	
	(0.266)	(0.278)	
5y on-the-run	0.850**	0.853**	
	(0.332)	(0.414)	
7y on-the-run	-0.124	-0.056	
	(0.222)	(0.347)	
10y on-the-run	0.434	0.122	
	(0.409)	(0.424)	
Time FE	YES	YES	YES
ISIN FE	YES	YES	YES
Observations	76,295	24,475	51,812
Number of ISIN	401	217	350
Ad. R-squared	0.505	0.530	0.504

Note: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1. Broker-to-broker activity, utilisation rate, average size of repo transactions and borrower concentration are all included in the estimates with a lag to address endogeneity issues.

Table B2: OLS panel estimates, second sub-period (11 June 2014 to 8 March 2015): Full sample, on-the-run sample and off-the-run sample

	Full sample	On the run	Off the run
Broker-to-broker activity	-0.014***	-0.014***	0.002
	(0.005)	(0.004)	(0.049)
Utilisation rate	0.010***	0.010**	0.010***
	(0.003)	(0.005)	(0.004)
Average size of repo transaction	-3.857***	-2.902	-3.923***
	(1.266)	(2.162)	(1.334)
Borrower concentration	-0.455**	-0.393	-0.382*
	(0.186)	(0.289)	(0.230)
Average tenure	-0.002***	-0.001**	-0.002***
	(0.000)	(0.001)	(0.000)
Time-to-maturity	0.321***	0.294***	-0.338
	(0.109)	(0.110)	(1.212)
Bid-ask spread	0.010	-0.002	0.019**
	(0.007)	(0.008)	(0.008)
Announcement	0.608**	0.661***	
	(0.236)	(0.255)	
Auction	-0.476**	-0.507**	
	(0.230)	(0.247)	
First day off	0.434		
	(0.402)		
1y on-the-run	-0.265	-0.288	
	(0.501)	(0.544)	
5y on-the-run	0.171	0.113	
	(0.214)	(0.206)	
7y on-the-run	0.044	-0.306	
	(0.153)	(0.217)	
10y on-the-run	-0.018	0.093	
	(0.374)	(0.360)	
Time FE	YES	YES	YES
ISIN FE	YES	YES	YES
Observations	48,015	18,960	29,046
Number of isin	375	205	296
Ad. R-squared	0.425	0.425	0.439

Note: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1. Broker-to-broker activity, utilisation rate, average size of repo transactions and borrower concentration are all included in the estimates with a lag to address endogeneity issues.

Table B3: OLS panel estimates, third sub-period (9 March 2015 to 21 September 2015): Full sample, on-the-run sample and off-the-run sample

	Full sample	On the run	Off the run
Broker-to-broker activity	-0.061*	-0.505***	-0.025
	(0.035)	(0.182)	(0.022)
Utilisation rate	0.006	0.014**	0.001
	(0.004)	(0.007)	(0.004)
Average size of repo transaction	-2.365	0.251	-2.695
	(2.075)	(2.546)	(2.302)
Borrower concentration	-0.456***	-0.384	-0.413**
	(0.155)	(0.328)	(0.176)
Average tenure	-0.002**	-0.005***	-0.001
	(0.001)	(0.002)	(0.001)
Time-to-maturity	0.139	0.003	-0.267
	(0.137)	(0.190)	(0.168)
Bid-ask spread	0.006	-0.003	0.005
	(0.006)	(0.008)	(0.007)
Announcement	0.864*	0.582	
	(0.462)	(0.528)	
Auction	-0.387***	-0.322*	
	(0.146)	(0.189)	
First day off	0.562*		
	(0.312)		
1y on-the-run	0.276	-0.058	
	(0.215)	(0.456)	
5y on-the-run	-0.186	-0.315	
	(0.207)	(0.613)	
7y on-the-run	-0.688	-0.074	
	(0.545)	(0.286)	
10y on-the-run	-1.067*	0.879**	
	(0.623)	(0.408)	
Time FE	YES	YES	YES
ISIN FE	YES	YES	YES
Observations	33,244	10,720	22,349
Number of isin	350	147	285
Ad. R-squared	0.271	0.282	0.283

Note: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1. Broker-to-broker activity, utilisation rate, average size of repo transactions and borrower concentration are all included in the estimates with a lag to address endogeneity issues.

Table B4: Tobit estimates, first sub-period (7 March 2013 to 10 June 2014): Full sample, on-the-run sample and off-the-run sample

	Full sample	On the run	Off the run
Broker-to-broker activity	-0.092*	-0.100**	-0.084
	(0.04)	(0.03)	(0.07)
Utilisation rate	0.022**	0.031**	0.015*
	(0.01)	(0.01)	(0.01)
Average size of repo transaction	-5.603*	-12.61**	-4.199
	(2.62)	(4.32)	(3.09)
Borrower concentration	-0.784*	0.405	-1.497***
	(0.34)	(0.45)	(0.42)
Average tenure	-0.004***	-0.006***	-0.003*
	(0.00)	(0.00)	(0.00)
Time-to-maturity	-0.007***	-0.009***	-0.007***
	(0.00)	(0.00)	(0.00)
Bid-ask spread	0.054**	0.038	0.067***
	(0.02)	(0.03)	(0.02)
Announcement	1.723***	1.895**	
	(0.51)	(0.70)	
Auction	-1.860***	-1.541**	
	(0.43)	(0.54)	
First day off	0.716		
	(0.44)		
1y on-the-run	0.067	-0.057	
	(0.56)	(0.62)	
5y on-the-run	1.327*	1.228*	
	(0.57)	(0.53)	
7y on-the-run	-0.111	-0.004	
	(0.35)	(0.59)	
10y on-the-run	0.565	-0.375	
	(0.69)	(0.95)	
ISIN FE	YES	YES	YES

Note: Robust standard errors in parenthese.s; ***p<0.01, **p<0.05, *p<0.1. Broker-to-broker activity, utilisation rate, average size of repo transactions and borrower concentration are all included in the estimates with a lag to address endogeneity issues.

Table B5: Tobit estimates, second sub-period (11 June 2014 to 8 March 2015): Full sample, on-the-run sample and off-the-run sample

	Full sample	On the run	Off the run
Broker-to-broker activity	-0.000	-0.016*	-0.000
	(0.00)	(0.01)	(0.00)
Utilisation rate	0.015**	0.014	0.017**
	(0.00)	(0.01)	(0.01)
Average size of repo transaction	-7.462***	-8.094***	-6.692**
	(1.61)	(2.75)	(2.11)
Borrower concentration	-0.417	-0.451	-0.305
	(0.28)	(0.46)	(0.33)
Average tenure	-0.002***	-0.002	-0.002**
	(0.00)	(0.00)	(0.00)
Time-to-maturity	-0.001	-0.003**	0.001
	(0.00)	(0.00)	(0.00)
Bid-ask spread	0.043***	0.041*	0.046***
	(0.01)	(0.02)	(0.01)
Announcement	1.472*	1.663*	
	(0.65)	(0.73)	
Auction	-0.235	-0.190	
	(0.36)	(0.36)	
First day off	0.734*		
	(0.36)		
1y on-the-run	0.839***	0.547***	
	(0.06)	(0.15)	
5y on-the-run	0.388	0.312	
	(0.37)	(0.36)	
7y on-the-run	0.121	-0.266	
	(0.33)	(0.52)	
10y on-the-run	-0.201	0.012	
	(0.40)	(0.42)	
ISIN FE	YES	YES	YES

Note: Robust standard errors in parentheses;***p<0.01, **p<0.05, *p<0.1. Broker-to-broker activity, utilisation rate, average size of repo transactions and borrower concentration are all included in the estimates with a lag to address endogeneity issues.

Table B6: Tobit estimates, third sub-period (9 March 2015 to 21 September 2015): Full sample, on-the-run sample and off-the-run sample

	Full sample	On the run	Off the run
Broker-to-broker activity	-0.057	-0.562*	-0.017
	(0.04)	(0.25)	(0.03)
Utilisation rate	0.008	0.020*	0.000
	(0.01)	(0.01)	(0.01)
Average size of repo transaction	-4.778	-2.117	-5.342*
	(2.46)	(3.30)	(2.64)
Borrower concentration	-0.569**	-0.784	-0.488*
	(0.22)	(0.50)	(0.24)
Average tenure	-0.002	-0.005	-0.001
	(0.00)	(0.00)	(0.00)
Time-to-maturity	-0.001	-0.004*	-0.000
	(0.00)	(0.00)	(0.00)
Bid-ask spread	0.008	-0.003	0.011
	(0.01)	(0.01)	(0.01)
Announcement	1.352	0.836	
	(0.70)	(0.79)	
Auction	-0.081	-0.418	
	(0.24)	(0.27)	
First day off	0.458		
	(0.37)		
1y on-the-run	0.429	1.221	
	(0.24)	(0.72)	
5y on-the-run	-0.180	-0.566	
	(0.25)	(0.78)	
7y on-the-run	-0.922	-0.147	
	(0.72)	(0.54)	
10y on-the-run	-1.581	0.850***	
	(0.96)	(0.20)	
ISIN FE	YES	YES	YES

Note: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1. Broker-to-broker activity, utilisation rate, average size of repo transactions and borrower concentration are all included in the estimates with a lag to address endogeneity issues.

Annex C: Panel estimates around policy changes

Table C1: The dynamics of specialness around policy changes – Full sample

	Negative deposit rate	ECB QE	ECB securities lending programme
Broker-to-broker activity	-0.203***	-0.096*	-0.034
	(0.076)	(0.051)	(0.064)
Utilisation rate	0.017***	0.012***	0.001
	(0.004)	(0.002)	(0.005)
Average size of repo transactions	-12.471***	-6.070***	1.729
	(1.989)	(1.361)	(2.564)
Borrower concentration	-0.370	-0.209*	-0.706***
	(0.229)	(0.127)	(0.259)
Average tenure	-0.001***	-0.001*	-0.000
	(0.001)	(0.000)	(0.001)
Time to maturity	-0.000	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Bid-ask spread	0.003	-0.017***	-0.045***
	(0.007)	(0.004)	(0.006)
On the run	-0.178*	-0.110	-0.071
	(0.103)	(0.078)	(0.123)
Post	-1.173***	0.314***	-2.114***
	(0.161)	(0.096)	(0.217)
Post_Broker-to-broker activity	0.100	0.053	0.065
	(0.080)	(0.058)	(0.074)
Post_Utilisation rate	-0.015***	-0.011***	0.018***
	(0.004)	(0.002)	(0.005)
Observations	2,786	2,850	2,864
Ad. R-squared	0.120	0.041	0.081

Note: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1. For each estimate, the estimation window is five days before and after the event.

Table C2: The dynamics of specialness around policy changes – On-the-run bonds

	Negative deposit rate	ECB QE	ECB securities lending programme
Broker-to-broker activity	-0.208	0.204	0.290
	(0.200)	(0.175)	(0.225)
Utilisation rate	0.009	0.001	0.007
	(0.008)	(0.004)	(0.008)
Average size of repo transactions	-9.162**	-8.833***	5.886
	(3.628)	(2.174)	(4.389)
Borrower concentration	-0.339	-1.235***	-1.048**
	(0.406)	(0.282)	(0.422)
Average tenure	-0.002**	-0.003***	0.001
	(0.001)	(0.001)	(0.001)
Time to maturity	-0.000	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Bid-ask spread	0.006	-0.017***	-0.052***
	(0.012)	(0.006)	(0.009)
Post	-1.180***	0.382*	-1.869***
	(0.285)	(0.217)	(0.358)
Post_Broker-to-broker activity	0.107	0.047	0.153
	(0.208)	(0.255)	(0.255)
Post_Utilisation rate	-0.008	-0.006	0.014*
	(0.008)	(0.005)	(0.008)
Observations	871	890	970
Ad. R-squared	0.092	0.056	0.112

Note: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1. For each estimate, the estimation window is five days before and after the event.

Table C3: The dynamics of specialness around policy changes – Off-the-run bonds

	Negative deposit rate	ECB QE	ECB securities lending programme
Broker-to-broker activity	-0.204**	-0.205***	-0.092*
	(0.081)	(0.039)	(0.051)
Utilisation rate	0.020***	0.017***	0.000
	(0.005)	(0.002)	(0.006)
Average size of repo transactions	-14.195***	-4.358***	0.903
	(2.466)	(1.665)	(3.080)
Borrower concentration	-0.397	0.085	-0.508
	(0.285)	(0.141)	(0.324)
Average tenure	-0.001**	-0.000	-0.001
	(0.001)	(0.000)	(0.001)
Time to maturity	-0.000	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Bid-ask spread	0.002	-0.016**	-0.036***
	(0.010)	(0.006)	(0.009)
Post	-1.190***	0.258**	-2.210***
	(0.195)	(0.104)	(0.265)
Post_Broker-to-broker activity	0.100	0.132***	0.065
	(0.086)	(0.048)	(0.059)
Post_Utilisation rate	-0.017***	-0.013***	0.019***
	(0.005)	(0.003)	(0.006)
Observations	1,915	1,960	1,894
Ad. R-squared	0.128	0.059	0.073

Note: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1. For each estimate, the estimation window is five days before and after the event.

Imprint and acknowlegements

The views expressed are those of the authors and do not necessarily reflect the views of the European Securities and Markets Authority. Any error or omissions are the responsibility of the authors. The authors would like to thank in particular Paolo Colla for the extensive feedback provided, and also Marina Brogi, Ana Escribano, Stefano Corradin, Manmohan Singh, Steffen Kern, Christian Winkler, Giuseppe Loiacono, Ricardo Crisostomo, Zijun Liu, Onofrio Panzarino, Gustavo Peralta, Josep Maria Vendrell-Simon, the ESRB Joint Expert Group on Shadow Banking, the ESMA Committee of Economic and Market Analysis and the ESMA Group of Economic Advisors, the participants to the conference Consob - Bocconi 'The Development of Securities Markets: Risks, Trends and Policies' on 26 February 2016, the participants to the conference 'EFMA 2016 Annual Meeting', and the participants to the 'ESMA workshop on collateral' on 18 January 2016 for useful discussions and comments.

Massimo Ferrari
European Securities and Markets Authority, Paris, France; e-mail: **massimo.ferrari@esma.europa.eu**

Claudia Guagliano
European Securities and Markets Authority, Paris, France e-mail: **claudia.guagliano@esma.europa.eu**

Julien Mazzacurati
European Securities and Markets Authority, Paris, France; e-mail: **julien.mazzacurati@esma.europa.eu**

© European Systemic Risk Board, 2017

Postal address	60640 Frankfurt am Main, Germany
Telephone	+49 69 1344 0
Website	**www.esrb.europa.eu**

All rights reserved. Reproduction for educational and non-commercial purposes is permitted provided that the source is acknowledged.

Note:
The views expressed in ESRB Working Papers are those of the authors and do not necessarily reflect the official stance of the ESRB, its member institutions, or the institutions to which the authors are affiliated.

ISSN	2467-0677 (online)
ISBN	978-92-95210-42-4 (online)
DOI	10.2849/906762 (online)
EU catalogue No	DT-AD-17-022-EN-N (online)