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On collateral: implications for financial stability and monetary policy

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Discussion papers

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Abstract

This paper examines the role of collateral in the financial system, with special emphasis on the implications for financial stability and the conduct of monetary policy. First, we review what drives the demand and supply for both real and financial collateral assets. Then we examine financial stability issues and the case for regulating the use of collateral. We discuss the role and design of market infrastructures such as central clearing counterparties (CCPs). Finally, we examine the interaction of standard and non-standard monetary policy and the functioning of private collateralised markets. We show that the use of collateral is neither a sufficient nor a necessary condition for financial stability. To ensure the stability of collateralised markets a mix of micro- and macro-prudential regulation, as well as a sufficient supply of safe public assets that can be used as collateral, are needed.

Keywords: Repo, haircuts, margins, central-clearing counterparties, central bank policies

JEL Codes: E59, E44, G18

Non-technical summary

This paper examines the role of collateral in the financial system, with a special emphasis on the implications for financial stability and the conduct of monetary policy. We argue that using collateral is no panacea to ensure financial stability. Collateralized transactions can be subject to pro-cyclicality, complex demand and supply concerns, as well as subject to intricate interactions of the public sector and private markets.

First, we review the theory of the use of collateral. We start building our arguments by examining the case of real collateral assets (e.g., land, houses or machinery) and then move to financial collateral assets. The use of collateral addresses asymmetric information and moral hazard problems in the economy while the safety and redeployability of an asset shapes its collateral quality. We argue that the amount of high-quality private collateral is necessarily limited by the very asymmetric information and moral hazard problems collateral is supposed to address. Governments in turn can create high-quality public collateral to the extent that they are not subject to asymmetric information and moral hazard problems. Ultimately, the key question, however, is not how much collateral assets there are, but how they are distributed in the financial system.

Second, we argue that using collateral is neither a sufficient nor a necessary condition for the efficiency and stability of financial markets. Using collateral may create new sources of financial market instabilities. Secured markets can "freeze", much like unsecured markets, and there can be amplification and contagion effects, especially when collateral assets are scarce.

Third, we review the economics of centralised clearing. Central clearing counterparties (CCP) can play an important role in making efficient use of collateral, provided they are well governed and their advantages in terms of economies of scale are used optimally.

Fourth, we examine the role the central bank. The design and implementation of central bank operating frameworks, as well as non-standard monetary policy in the form of large-scale asset purchases have become critical for the working of secured markets. We present evidence for the significant influence of Eurosystem eligibility criteria and collateral haircuts (especially relative to CCP haircuts) on markets involving collateral assets.

A number of messages arise from our analysis.

First, collateral and margin requirements in private financial markets, even those with central clearing, may be too pro-cyclical, leading to excessive leverage and over-borrowing in good times, and excessive de-leveraging and asset sales when in bad times. These inefficiencies call for macro-prudential regulation to correct the externalities, e.g., by requiring capital buffers even for secured transactions and imposing upper and lower limits on the use of margin requirements (a form of collateral use).

Second, CCPs can bring about netting and collateral savings benefits, as well as risk reduction but clearing arrangements must be designed to preserve clearing members' incentives for prudent risk-management, as well as to mitigate potential moral hazard stemming from the too-big-to-fail problem.

Third, central bank operations, due to their collateralised nature, interact with, and affect the functioning of, the secured markets in complex ways. Our discussion highlights how central bank operations can improve liquidity and market functioning. However, they can also "withdraw" collateral assets, which may contribute to a scarcity of good collateral and to the "specialness" of some assets or asset classes.

In sum, ensuring a smooth functioning of secured (and unsecured) markets is an important, yet challenging task. It requires, inter alia, micro-prudential supervision to address weaknesses in individual bank balance sheets, macro-prudential regulation to address market failures in collateralised markets, as well as a sufficient supply of safe public assets that can be used as collateral in secured markets. Moreover, central bank operations can change the composition of collateral assets in financial markets, and affect the collateral use of private agents in complex ways.

1. Introduction

In the aftermath of the global financial crisis, as well as the European sovereign debt crisis, there has been a strong upward trend in the use of collateral to back up financial transactions. Prior to 2007, around 60 percent of the turnover in euro money markets was secured (ca. EUR 25 trillion out of EUR 40 trillion overall). By 2015, this share has increased to 90 percent (ca. 29 trillion of EUR 32 trillion overall) (Figure 1).

In this paper, we examine the role of collateral in the financial system. What exactly does it mean to collateralise a transaction? What are the benefits and costs of doing so? Will markets, left to their own devices, use the "right" amount of collateral? Or is there a need to regulate the use of collateral?

We answer this set of questions in the first half of the paper. We start building our arguments by examining the demand for collateral in the case of real assets (e.g., land, houses or machinery). The theory of collateral demand focuses on who has control over the collateral asset and when. This in turn determines the impact of collateralisation on loan terms and also is critical when determining the quality of collateral. The evidence supports the view that collateralisation addresses asymmetric information and moral hazard problems in the economy while the safety and redeployability of an asset shapes its collateral quality.

The basic logic also applies in the case of financial collateral assets. But the issue of financial collateral is much richer. In financial markets, agents often borrow the asset instead of cash. It also is much easier to modify who has control over an asset when it is a financial rather than a real one. Moreover, collateral appears not just in lending but also in hedging. Margins are collateral in the context of derivatives.

Private markets can produce collateral, but the supply of high-quality private collateral is necessarily limited by the very asymmetric information and moral hazard problems collateral is supposed to address. Governments in turn can create high-quality public collateral to the extent that they are not subject to asymmetric information and moral hazard problems. Ultimately, the key question, however, is not how much collateral assets there are, but how they are distributed in the financial system.

We argue that secured markets are not a panacea. They may be prone to instabilities and market "freezes", very much like unsecured markets. Moreover, there are important amplification and contagion effects via the price of collateral assets, in particular when they are scarce.

Collateral and margin requirements in secured and derivatives markets determine the extent to which market participants can lever up their own capital. In good times, low collateral and margin requirements allow for higher leverage. When bad shocks hit, the requirements can increase abruptly and create de-leveraging pressures. Thus, variation in collateral requirements goes hand in hand with variation in leverage, and can have a large impact on asset prices and the macro-economy.

Having established that using collateral is neither a sufficient nor a necessary condition for the efficiency and stability of financial markets, we ask in the second half of the paper: what type of market design and what type of central bank behaviour improves the functioning of secured markets?

Market infrastructures such as central clearing counterparties (CCPs) have received a lot of attention recently. For example, the European market Infrastructure Regulation in Europe (EMIR) as well as the Dodd-Frank Wall Street Reform Act in the U.S. require certain derivative trades to occur via CCPs. Yet, there is considerable debate about the optimal design of CCPs. In the euro area, the majority of secured transactions now occur via CCPs (Figure 2).

We review the main potential benefits of CCP clearing: mutualisation of counterparty risk, economising on scarce collateral, enhancing transparency, and setting of stricter margin and haircut requirements. The key issues of optimal CCP design are their governance and risk-management practices, their systemic nature, and the interaction of CCPs with the financial markets at large.

Finally, we examine the role of central banks. The design and implementation of central bank operating frameworks has become critical for the working of secured markets. The implementation of standard monetary policy occurs mostly via secured lending and repos. The use of collateral in these operations has risen considerably in the aftermath of the financial crisis as central banks increased the supply of (public) liquidity in the form of central bank money. Moreover, central bank asset purchases and regulatory changes (e.g., liquidity regulation, leverage ratio) further impact the demand and supply of collateral assets.

The evidence presented in this paper indicates that the influence of the Eurosystem on markets for collateral assets is significant. The liquidity facilities of the Eurosystem, its collateral policy which kept haircuts on euro area sovereign bonds practically constant and at a lower level than those applied by CCPs, and, crucially, the Fixed Rate Full Allotment (FRFA) policy, are likely to have played a critical role in alleviating euro area banks' funding liquidity stress. We observed high degree of substitution between private repo funding and the liquidity provided by the Eurosystem.

We also show that central bank operations have effects on the availability of collateral and its pledgeability in private markets, and on the price of collateral in some instances. We discuss how the Eurosystem eligibility criteria might have induced market participants to issue and structure assets to meet its eligibility criteria. In addition, we present recent empirical evidence on how changes in its haircut policies affected bond prices.

2. Collateral: conceptual issues

This section first explains why contracting parties demand collateral, what is the cost of using collateral, and what is good collateral. Then we ask how the private and the public sector can create collateral assets. To illustrate the various issues, we distinguish between real and financial assets. The basic principles are more transparent for real assets because financial assets add new dimensions (e.g., reverse repos and the issue of borrowing to obtain the collateral asset instead of cash).

2.1. Demand for real collateral, cost of collateral, and what is good collateral?

In its most basic form, collateral is an asset (physical like property or machinery, financial like a bonds or equity) that a borrower offers a lender to secure a loan. The lender has the right to take possession of the collateral if the borrower defaults on the loan.[2]

Demand for collateral

There are three main reasons why contracting parties demand collateral.

First, being able to take possession of an asset gives the lender the opportunity to receive some payment in case of the borrower's default. Either the lender can use the asset himself, or he can sell it. Being able to receive some payment in case of default makes it more attractive for the lender to extend a loan. With collateral, the lender is more willing to reduce the interest rate, offer longer maturities, make larger loans and finance riskier borrowers.

A second role of collateral is the improvement of borrower incentives to repay the loan. In many cases the probability of borrower default is endogenous (moral hazard). Default depends not only on shocks outside the control of the borrower but also on her (unobservable) behaviour. Posting collateral has the potential to reward good behaviour and punish bad behaviour. As long as good behaviour increases the likelihood of loan repayment, and bad behaviour increases the probability of default, collateral makes loan repayment more likely. The borrower keeps the collateral in case of loan repayment and loses it in case of default. This induces the borrower to strive for loan repayment and avoid default.[3][4]

[2] The view that financial contracts such as debt contract not only confer rights to cash flows but also the right to take control of assets such as collateral (i.e., the so-called "incomplete contracts" view pioneered by Grossman and Hart, 1986) is formalized in the seminal paper by Aghion and Bolton (1992).

[3] See, for example, Boot et al. (1991). Instead of posting existing and future assets as collateral, borrowers can also invest less and post the remaining cash as collateral. To the extent that the moral hazard problem relates to managing the investment, this improves incentives by limiting the size of the investment. For an application of this idea, see Acharya and Viswanathan (2011) and Biais et al. (2016).

[4] Pledging assets as collateral not only affects the incentives of borrowers but also those of lenders. When there is asymmetric information about their creditworthiness, collateral can worsen a lender's incentive to

A possible third role of collateral is the signalling financial strength.[5] Consider the case in which a lender knows less about the creditworthiness of a potential borrower (asymmetric information). Then a borrower can signal a high likelihood of repayment by posting collateral. Given her high likelihood of repayment, the borrower will rarely incur the cost of losing the collateral. In contrast, a borrower with a low likelihood of repayment finds it too costly to post collateral as she loses the collateral often. She therefore posts no (or less) collateral. The amount of collateral therefore provides information about the otherwise unobservable likelihood of debt repayment.

The evidence supports the view that collateral improves the incentives of a borrower to repay a loan. Loans are more heavily collateralized when borrowers appear to be riskier according to information available to lenders, e.g., in credit registers (Jimenez et al., 2006; Berger et al., 2011). The alternative hypothesis---collateral signals high borrower credit-worthiness---receives less support in the overall data. In certain specific circumstances signalling/screening, however, seems to occur, for example when there is no prior relationship between borrower and lender, or when borrowers are young and without much credit history.

Cost of using collateral

Posting assets as collateral is costly because a transfer of collateral from the borrower to the lender creates a loss of value. Asset used as collateral for loans are naturally worth more to the borrower than to the lender when they enter the loan contract. Take the example of the mortgage secured with the house as collateral. The borrower bought the house for a specific reason, either as an investment that fits his needs or because he want to live in the house. The bank has no such use for houses. Obviously the bank has no interest in using houses for accommodation, nor is it (primarily) in the business of holding a stock of houses for investment purposes.

There are many other reasons why a transfer of assets from the borrower to the lender implies a deadweight cost. The original owner may have learnt information about the asset that the next owner does not have because he has not been in possession of the asset. A similar deadweight cost occurs when assets require maintenance. The owner of an asset has a higher incentive to maintain the quality of an asset than someone who just happens to obtain possession of the asset in case a loan defaults. In addition, an asset owner's incentive to maintain quality diminishes as the loan moves closer to default because it becomes more likely that the benefits of maintenance no longer accrue to him (for evidence of this in the housing market, see Melzer, 2016).

Empirically, the cost of transferring collateral assets from borrowers to lenders is a key determinant of the cost of debt. When assets are more redeployable, and hence the transfer cost is low, borrowers receive larger and cheaper loans, and obtain better credit ratings (Benmelech and Bergman, 2009).

screen borrowers (Manove et al., 2001). For related analyses of lender incentives, see Rajan and Whinton (1995) and Inderst and Mueller (2007).

[5] See Bester (1985, 1987).

What assets are good collateral?

The cost of using collateral and the conditional transfer of collateral in default go hand in hand. Although more collateral always makes the lender's claim safer, the transfer of collateral to the lender is costly. The optimal arrangement therefore concentrates the use and transfer of collateral to those circumstances where collateral is most efficient, which is when the borrower defaults.

In the light of this logic, the "quality" of collateral is defined by its safety and its liquidity (i.e., transferability). An asset is good collateral when it is robust to borrower default. In that respect, the length of the period until final repayment (i.e., the maturity of a loan) matters. When the period is longer, then circumstances in which a borrower defaults can occur more often. Hence, loans with longer maturity tend to be less liquid.

The house securing a mortgage may not be good collateral if the value of the house is correlated with the borrower losing his job. Such a correlation happens, for example, when an entire economic area is hit by a negative shock. Then the borrower may lose his job (because his employer does poorly) and local house values fall (because there is little demand for houses as many other people lose their job) at the same time. Hence, whether an asset is good collateral or not only depends on the characteristics of the asset, but also on market conditions (see Shleifer and Vishny, 1992). We develop this point more in Section 3.1, which deals with general equilibrium issues.

An asset is also good collateral if it is liquid, i.e., there is little loss of value when the asset is transferred from a defaulted borrower to his lender. In line with the reasons above for the deadweight cost of transferring collateral, liquid collateral is an asset whose value is not owner specific. Liquid collateral also does not require maintenance and is transparent (easy to value).

2.2. Financial collateral

The previous section dealt with real (or non-financial) assets as collateral, e.g., a house securing a mortgage or plant, property and equipment securing a commercial loan. This section extends the arguments to financial collateral, i.e., when the underlying asset is a government bond or shares in a company.

The main economic arguments about the role of collateral apply independently of whether the asset is a real or a financial one. Collateral improves borrower incentives and may signal creditworthiness. The redeployability and safety of financial assets determine collateral quality and hence the cost of using collateral.

Nevertheless, some new issues arise when financial assets serve as collateral. First, there is some terminology specific to transactions with financial collateral (haircut, margins). Second, the typical transaction with real collateral (as described in the previous section) is a secured loan. Repo transactions, which are an important part of the financial system and a key place where the role of collateral manifests itself, resemble secured loans but differ somewhat in who has control over the

collateral when.[6] Finally, we examine collateral in the context of derivative contracts. Again, there are similarities and differences with secured lending.

Some terminology: haircuts and margins

The relative size of the loan volume and the value of the collateral (the assets sold and repurchased) define the "haircut" or "margin" required. The haircut is given by 1-(loan volume/value of collateral), while the margin is given by (value of collateral/loan volume)-1. If a borrower has to post collateral worth 100 to borrow 80, then there is a 20% (0.2=1-80/100) haircut and a 25% margin (0.25=100/80-1). If the borrower is able to borrow 90, then the haircut falls to 10% and the margin falls to 11%.

The haircut can be compared to a down-payment. A down-payment of 20% means that to buy, say, a house worth 100 one has to use 20 of one's own capital. In such a transaction, the buyer obtains a loan worth 80 (the mortgage) against collateral worth 100 (the house), which implies a haircut of 20%.

The haircut is a measure of the use of collateral (normalized by the size of the loan). The haircut increases when more collateral effectively backs the loan. The haircut should therefore reflect borrower risk and asset re-deployability along the same lines as in the case when non-financial assets serve outlined in the previous section. Evidence confirms that haircuts are larger when lenders are exposed to more counterparty risk or when the collateral asset is less liquid (Auh and Landoni, 2015).

Repos vs. secured lending[7]

In a repo transaction, the borrower sells the asset to the lender for cash and, at the same time, acquires the right to repurchase the asset at the original price plus an extra amount at a pre-specified future date. A repo is a form of secured lending where the loan volume is the price at which the asset (the collateral) is sold, the interest rate is given by extra amount needed to repurchase the asset, and the repurchase date gives the maturity of loan.

Even though a repo contract functions much like a secured loan, two extra issues typically arise: re-hypothecation and the exemption from automatic stay.[8]

[6] The semi-annual survey of the repo market in Europe conducted by the International Capital Market Association shows a volume of outstanding transaction in December 2015 of EUR 5.6 trillion (see also ECB, 2015, chapter 4; and ICMA, 2015). For the U.S. studies estimate the total size of the repo market at the end of 2015 at around USD 5 trillion (Baklanova et al., 2015; see also Adrian et al., 2014).
[7] For more detailed information about the functioning of repo markets, see CGFS (2017).
[8] The concepts of re-hypothecation and exemption of automatic stay are logically distinct from repos and the embedded repurchase agreement. Legal provisions can amend secured loans so that there too collateral can be re-hypothecated and is exempt from automatic stay. However, the concepts always appear in repo contracts. Moreover, we focus on economic concepts. The legal interpretation or re-hypothecation may be subtly different across legislations (see Comotto, 2014). For more information about the institutional details of repo markets, see http://www.icmagroup.org/Regulatory-Policy-and-Market-Practice/repo-and-collateral-markets/ .

Normally, in a secured loan the borrower has control of the collateral asset as long as he does not default. In a repo contract the lender typically has control of the collateral asset until it is repurchased by the borrower. Hence, the lender can use the asset as she pleases until she has to return it to the borrower. This process of re-using the collateral asset is called re-hypothecation. For example, the lender can sell the asset now, buy it back later (before it is repurchased by the borrower) and make a profit if the price of the asset falls in the meantime.

In a reverse repo, the "borrower" does not enter the transaction to obtain cash, but to obtain the security. For example, suppose a hedge fund sells short a certain security. In order to deliver a security it does not own, the fund engages in a reverse repo transaction to obtain the security from a securities lender.[9] Of course, at maturity the hedge fund has to buy the security from someone in order to deliver it back to the securities lender.

Giving the lender the control right over the borrower's asset during the time of the repo transaction can be optimal when the asset is scarce (Gottardi et al, 2015; Maurin, 2015). The market appears to attach a premium to government bonds because they are good collateral (Bartolini & al., 2011). The supply of safe and liquid government bonds enhances the making of financial transactions---such bonds perform a similar function as money does for real transactions (Krishnamurthy and Vissing-Jorgensen, 2012). We come back to the issue of the scarcity of collateral assets in Section 2.3.

Giving the lender the control right over the borrower's asset also provides maximal protection in case the borrower defaults. Repo transactions, unlike secured loans, are typically exempt from automatic stay when bankruptcy occurs. Automatic stay prevents secured creditors from rushing in and seizing the collateral assets from the borrower. The idea is to gain time for a possible reorganisation of the borrower's business or, alternatively, for an orderly liquidation of his assets. The lender in a repo transaction does not have to wait. She has already control of the collateral asset and can immediately sell it once bankruptcy voids the borrower's repurchase right.

A repo lender's ability to turn collateral into cash quickly after a borrower defaults enhances debt capacity and lowers the cost of debt. Given the control right to the lender increases the effective liquidity of collateral asset, which undoubtedly contributes to the attractiveness and development of repo markets. But it may lead to too much asset sales from the point of view of the economy as a whole. As lenders quickly sell collateral assets, the price of these assets falls as the supply to the market increases. Such a "fire-sale" may have adverse consequences for market participants. We examine the fire-sale externality of collateral and possible market and regulatory responses to it in more detail in Section 3.1. Here we just note here that the externality may be more severe for repos than for other forms of secured lending because of the exemption from automatic stay (Antinolfi et al. 2015).[10]

[9] A reverse repo contract is similar to leasing a real asset. For example, airlines often lease their aircrafts from specialized aircraft lessors instead of owning them (see Gavazza, 2011). This then raises the related question why a financial asset is borrowed in a reverse repo instead of purchased. One possibility is that the reverse repo protects the borrower of the security against price movements. The repurchase commitment by the securities lender means that the price of "selling" the security in the future is known today (for a model of this, see Gottardi et al., 2015).

[10] Bolton and Oehmke (2015) also examine the cost and benefit of the exemption from automatic stay for derivatives. In terms of repos (the forward to buy the asset at a future date is a derivative), their analysis

The flipside of giving the lender protection against borrower default is the possibility of lender default. The cash lender is effectively a borrower of the security. The cash borrower therefore may not be able to repurchase the security when the cash lender defaults. In that case the cash borrower loses the haircut, i.e., he loses the difference between the cash he received and the value of the collateral asset. Consequently, the pricing of repo contracts (rates and haircuts) not only reflects the characteristics of cash borrowers and of the underlying collateral, but also that of cash lenders (Auh and Landoni, 2015).

The default of cash lenders in repo markets in conjunction with re-hypothetication may render repo markets fragile. We noted the similarity between money and the re-use of high quality collateral in repo transactions. But unlike cash, the re-use of collateral creates a chain of repo transactions. As the default of cash lenders is costly to cash borrowers, who themselves may be cash lenders, the default of a lender can be contagious and ripple through the repo chain (Maurin, 2015). Central clearing counterparties (CCPs) that intermediate repo transactions can reduce the fragility of repo chains by netting positions and mutualisation across counterparties. We analyse these issues in Section 3.2.

So far, we examined the role of collateral in secured lending and repos between private parties. Secured lending and repos also play a key role in the implementation of monetary policy. Central Banks typically use various forms of secured lending and repos with eligible counterparties in their open market operations. In Section 4 we examine in detail how collateral is used in the ECB's open market operations and how these operations interact with the functioning of financial markets.

Derivatives, margins and collateral

Financial markets not only channel resources from savers (lenders) to investors (borrowers), e.g., in the form of secured lending, but they also distribute risks across market participants. Derivatives contracts are the main tool to achieve risk-sharing in financial markets.[11]

Margins are collateral in the context of derivatives. The insurance provided by derivative contracts is effective only when counterparties honour their contractual obligations, i.e., when there is no counterparty default. In order to protect against default, counterparties call margins.

For example, suppose someone who is averse to risk wants to lock in today the price for the future purchase of oil for example. He can do so by purchasing a forward contract from someone who is less risk averse. The forward contract insures him against price fluctuations. If the price of oil has risen by the time delivery occurs, he makes a gain and the person who sold the forward (the insurer) makes a loss. In order to protect against this loss, the insurer has to post collateral.

shows that the effective seniority of repos in bankruptcy increases the risk for other secured and unsecured claim holders.

[11] The Bank for International Settlements estimates the notional amount outstanding of the over-the-counter derivatives in the second half of 2015 at USD 493 trillion (with a gross market value of USD 14 trillion). Most of these derivatives are written on interest rates. In addition, there are USD 25 trillion of futures and USD 38 trillion of options trades on exchanges (notional amounts). The data is available at http://www.bis.org/statistics/about_derivatives_stats.htm.

Derivative positions are evaluated not just at the end of the contract but also during the life of the contract (mark-to-market). At delivery, it may be too late to ask the insurer to post collateral to cover her loss incurred by the difference between the forward and the spot price. If the insurer defaults on the forward contract, she may also not be able to post collateral anymore. Instead, using the example above, the insurer has to post collateral as soon as the price of oil starts to increase. After an increase, it is more likely that she makes a loss than a gain on the forward contract. Posting collateral after an increase in the price of oil (i.e., having a margin call) protects the insured against counterparty risk as soon as the derivative position turns into an expected liability.

As in the case of secured lending, posting collateral in the context of derivatives (and the liabilities they entail) has benefits and costs. First, as in secured lending, margins ensure the presence of collateral to cover losses from derivative positions. Second, posting margins also can have important incentive effects (Biais et al., 2016).[12] As in secured lending, posting margins improves the incentives of counterparties for prudent behaviour. The threat of losing the margin makes counterparties internalize the cost of actions that increase the likelihood of defaulting on the derivative contract.[13]

The cost of posting a margin is slightly different than the cost of posting collateral in a secured loan (Biais et al., 2016). In a secured loan, the asset is transferred to the lender once default occurs. In a margin call, the asset is transferred when the derivative position becomes a liability, which occurs well before default occurs.[14] As a result of margin calls, counterparties have to give up resources that they could have put to use elsewhere more productively.

2.3. Public and private supply of collateral

While collateral has many benefits, its use involves a deadweight cost. Posting collateral means that the first-best user of capital will lose control over the asset in some states of the world. The deadweight cost is smaller, the smaller is the difference between the first-best and the second-best user of an asset and the smaller is the cost of transferring the asset between them.

We explained that a high-quality collateral asset has a small deadweight cost because it is safe and liquid. When an asset is safe, it does not matter much who owns it, and when it is liquid, it can be easily transferred across owners. Even though safety and liquidity are distinct concepts (the house securing a mortgage is safe but illiquid), they are closely related, especially in the case of financial assets (see Golec and Perotti, 2015).[15]

The private market can "produce" high quality collateral, but only up to a point. Hence, good private collateral is necessarily scarce (Holmström and Tirole, 1998). By holding or investing in safe and

[12] The incentive benefit of margins is also recognized in the recent policy debate, see for example BCBS (2015).
[13] For a case study of entering derivative and reverse repo transactions, collateral and incentives for risk-taking, see the case of AIG as described in McDonald and Paulson (2015).
[14] In that sense, margin calls are similar to repo contracts. They both transfer the control right over the collateral asset away from the "borrower" before default occurs.
[15] For evidence that safety and liquidity are not the same even in the case of financial assets, see for example the "on-the-run phenomenon", i.e., the fact that the most recently issued government bonds are more expensive and liquid than previously issued government bonds (see Pasquariello and Vega, 2009). For an empirical approach to disentangle credit from liquidity risk with an application to the euro area sovereign bond market, see Schwarz (2016).

therefore low return assets, the private market forgoes profits. Profit maximisation induces firms to invest into riskier, higher-yielding assets. But riskier assets are prone to asymmetric information and moral-hazard problems. The return on (portfolios) of risky assets depends how well they are managed, which is mostly unobservable to outsiders. Potential misbehaviour increases the riskiness of private assets and limits their role as collateral.

One should not confuse the production of the aggregate amount of high quality collateral in the private market with the distribution of such collateral across the market. As the overall amount of private high quality collateral is necessarily limited, the appearance of new high-quality private collateral in some part of the financial system must come at the expense of new low-quality private collateral in some other part. For example, the shadow banking system can transform risky assets into high-quality collateral (with money-like attributes as described above) in normal times, but at the expense of illiquidity in crisis times (Moreira and Savov, 2016).[16]

Given the scarcity of private high-quality collateral, there is a role for the government to expand the supply of high-quality collateral by issuing government debt (Holmström and Tirole, 1998). Because the government has the power to tax and audit firms (and people), it does not face the incentive constraints of the private sector.[17] Consequently, government debt typically is safe and liquid, and serves as high-quality collateral that expands the scope of private financial transactions.[18]

Owing to the safety and liquidity of government bonds and hence their special role as collateral, theory predicts that government bonds contain a liquidity premium. Like money, the private market is willing to hold these assets for their transaction purpose. Krishnamurthy and Vissing-Jorgensen (2012) confirm this prediction empirically for U.S. Treasuries and, moreover, trace out the demand curve by exploiting historical variation in the supply of government bonds. When Treasuries are scarce, their liquidity premium is larger.[19]

While public debt can enhance the functioning of financial markets because public debt is good collateral, such "extra liquidity" may not be distributed efficiently in the economy, especially in times of crisis (in so-called "flight-to-quality" episodes). Uncertainty, market power or symmetric information problems may lead to an inefficient hoarding of liquidity by some.[20] In these circumstances, there is a role for central banks to overcome coordination failures among private agents and to ensure an efficient distribution of liquidity in the financial system.

[16] The same logic also applies to international financial markets. For more information about the issue of global safe assets, see Bernanke (2005) and Caballero et al. (2008, 2016). Gourinchas and Rey (2016) argue that providing safe global assets exposes the issuer, e.g., the U.S. or, more recently, Germany, to global shocks.
[17] The government may, however, face different incentive problems. The European sovereign debt crisis shows that not all government debt is deemed good collateral. The political economy and fiscal issues involved are beyond the scope of this paper. For an analysis of how government fundamentals affect the creation of safe assets in an international aspect (and with an application to the euro area), see He et al. (2016a).
[18] Woodford (1990), in the context of an overlapping generations model, also argues that government bonds improve welfare when there are private liquidity-constraints.
[19] In Heider and Hoerova (2009) the scarcity of collateral leads to volatility in secured markets and a decoupling of secured and unsecured bond prices when credit risk leads agents to hold more secured bonds.
[20] In Caballero and Krishnamurthy (2008) each economic agent behaves as if he expects the worst-case scenario, even though collectively, this scenario is impossible. In Heider et al. (2015), agents anticipate a break-down of the market for liquidity caused by asymmetric information. In Acharya et al. (2012) liquidity-rich banks with market power squeeze liquidity-poor banks to gain market share.

2.4. Shortages of high-quality collateral

High-quality collateral, especially the one supplied in the form of government bonds, is in high demand in the private market when there is stress in the financial system. Figure 3 illustrates this for the euro area. The figure shows the 3-month government bond yields of Germany and Italy relative to the ECB's Deposit Facility (DF) rate. The figure also plots the Corporate Indicator of Systemic Stress (CISS) to capture episodes of heightened financial stress (see Holló, Kremer and Lo Duca, 2012).

When the yield of a government bond falls below the DF rate, this can indicate collateral scarcity. Financial actors with cash (and access to the central bank) are willing to pay more for the government bond than for storing the cash at the central bank (i.e., the safest possible way). Those actors must therefore want the government bond and value its possession over and above its use as storage for cash (see also He et al., 2016b).

The yield of both German and Italian bonds drops below the DF rate during the height of the financial crisis in October 2008. This indicates a general flight to safety into publicly provided collateral. Then during the sovereign debt crisis in Europe (mid 2011-mid 2012), only the German bond drops below the DF rate. This indicates now a flight to safety into the safer core of the euro area, in particular Germany as the de facto safe asset of the euro area. Both these episodes line up with spikes of the CISS as one would expect for the financial and sovereign debt crises.

Since mid-2015, there appears to be a scarcity of safe assets in the euro area even though there is no flight to safety because of a financial crisis. The yields of government bonds, and again especially those of safer countries such as Germany, drop again below the DF rate. But now, unlike previously, there is no obvious sign of stress in financial markets. The CISS indicator is well below the spikes in October 2008 and in the period from mid-2011 to mid-2012.

The recent episode of collateral scarcity in the euro area is probably caused by a combination of tighter regulation requiring financial actors to hold more collateral for certain transactions (e.g., derivative trades), fiscal austerity limiting the supply of government bonds, and central bank asset purchases that withdraw some high-quality collateral from private markets.

3. Collateral and clearing: financial stability, efficiency and regulatory policies

In this section, we first explain under what conditions collateralised markets can contribute to the pro-cyclicality in the financial system and even sow the seeds of future financial fragility. We discuss how the inefficiencies we identify can be corrected by macro-prudential regulation. We then turn to the economics of Central Clearing Counterparties and describe their role in economising on scarce collateral and improving market resilience.

3.1 Collateral: pro-cyclicality, financial stability and efficiency

Collateral and margin requirements set by market participants may be pro-cyclical, with low collateral and margin requirements in good times and large – and potentially sudden – increases in the collateral and margin requirements in periods of market turbulence. Collateral and margin requirements determine funding conditions and the extent to which market participants can lever up their own capital. Low collateral and margin requirements allow for higher leverage. Therefore, pro-cyclicality of collateral and margin requirements goes hand in hand with pro-cyclicality of leverage in the financial sector. And leverage can have large amplifications effects on the macroeconomy: small, temporary shocks to technology or income distribution can generate large, persistent fluctuations in output and asset prices (Kiyotaki and Moore, 1997).

There is empirical evidence that marked-to-market leverage is indeed strongly pro-cyclical (see, e.g, Adrian and Shin, 2010). In particular, those financial intermediaries whose net worth is sensitive to fluctuations in asset prices actively adjust their balance sheets to changes in their net worth, and do so in such a way that leverage is high during booms and low during busts. The leverage is financed primarily through borrowing in secured, repo markets. That is, an important source of pro-cyclicality is the link between leverage and asset prices. This link was analysed in a number of recent theoretical contributions.

For example, low collateral / margin requirements in financial markets lead to higher leverage and asset price booms in times of generalised optimism (Geanakoplos, 2010). Assets are bought by investors who are most optimistic about future asset prices, and low margins allow those investors to borrow more and to purchase more, thus fuelling asset price increases. When bad shocks hit the economy, margins increase, asset prices fall and volatility increases. This generates losses for the most optimistic, leveraged investors. The feedbacks between volatility, tightening margin constraints and losses by highly leveraged investors further amplify the negative effects on asset prices. This dynamics gives rise to the so-called "leverage cycles".

Asset price declines can be particularly severe when adverse shocks happen in good economic times (Acharya and Viswanathan, 2011). In good times, short-term debt used to finance asset purchases is cheaper, and financial firms can be highly levered. But if an adverse shock hits, high-leverage firms have an incentive to shift risk and therefore lenders do not roll over their debt. These firms have to de-lever by selling assets to a few firms that are less levered, which have a limited capacity to absorb large amounts of assets being sold. This leads to low, “fire-sale”, prices so that tighter funding

constraints – difficulties to roll-over credit - coincide with limited market liquidity, a phenomenon observed widely in the recent financial crisis.

Moreover, adverse shocks to funding liquidity and market liquidity can become mutually reinforcing (Gromb and Vayanos, 2002; Brunnermeier and Pedersen, 2009). An initial adverse shock to asset prices can be amplified if potential buyers of assets are collateral-constrained and falling asset prices tighten their constraints further. Reduced market liquidity leads to even lower asset prices and increased volatility, triggering further margin calls and creating a negative feedback loop between tightening funding constraints and asset prices.

Pro-cyclicality affects not only funding markets but also markets for hedging risk through derivatives (Biais, Heider and Hoerova, 2016). Derivatives contracts with large exposures and higher counterparty risk are more likely to be underwritten in good times when the perceived macroeconomic risk is low and adverse shocks seem unlikely. In this case, if bad news about derivatives positions do arrive, exposed investors engage in risk-taking and become more likely to default. By contrast, when macroeconomic risk is perceived to be high, derivatives contracts limit exposures and the associated counterparty risk. Margin requirements in derivatives contracts arise as a mechanism to tame risk-taking and reduce counterparty risk. Since risk-taking incentives are higher following adverse shocks, margin calls will be naturally made following negative news, which also contributes to pro-cyclicality, and can lead to financial instability, the issue we address next.

Markets in which collateral / margin constraints play a role can be fragile and subject to “panics”: mere expectations of fire-sales prices for collateral assets can be self-fulfilling and lead to large asset sell-offs and price drops (Biais, Heider and Hoerova, 2015; Brunnermeier and Pedersen, 2009; Kuong, 2014). In the context of collateralised debt markets, when the re-sale price of collateral is expected to be low, lenders demand more collateral and higher repo rates, making it more attractive for borrowers to engage in risk-taking ex-ante. The riskier pool of projects leads to more liquidation ex-post and hence more seized collateral to be sold off, which depresses asset prices and justifies the expectation of fire-sales. In the context of derivatives markets, margin calls provide insurance against counterparty default and when margin calls are made, assets are liquidated to satisfy them. Low expected asset prices imply that a large amount of assets must be liquidated to provide enough insurance. Once again, a lot of liquidation depresses asset prices, thus confirming initial expectations.

Even when feedback loops between collateral values and asset prices are absent, short-term collateralised debt markets can be fragile. Fragility can be linked to the dynamics of the production and evolution of information about collateral quality (Gorton and Ordoñez, 2014). Short-term collateralised debt is efficient if agents are willing to lend without producing costly information about the underlying collateral. In this case, even borrowers with low quality collateral can borrow, and a generalised credit and economic boom ensues. As information about borrowers decays over time, a small shock can cause lenders to suddenly have incentives to learn the quality of underlying collateral. Borrowers either de-lever to avoid costly information production or lose credit if their collateral is bad, which leads to a decline in credit and output.

Fragility in collateralised markets can spill-over into the uncollateralised market (Ranaldo, Rupprecht and Wrampelmeyer, 2016). This occurs when borrowers are constrained in both secured and unsecured markets so that a loss of funding liquidity in the secured market cannot be substituted by

borrowing in the unsecured market. In this case, after an adverse shock hits, margins increase and funding constraints in the secured market tighten. As a result, leverage goes up, which increases counterparty credit risk and unsecured interest rates, raising the cost of borrowing unsecured. Therefore, funding illiquidity in the secured market may be accompanied by the funding illiquidity in the unsecured market.

Not only are outcomes in collateralised markets subject to fragility and self-fulfilling panics, outcomes in those markets may be inefficient from the social point of view. The wedge between privately-optimal and socially-optimal decisions can be driven in particular by the failure of individual private agents to recognise that their leverage decisions impact the ability of other agents to leverage (Geanakoplos, 2010) or to borrow in the unsecured market (Ranaldo, Rupprecht and Wrampelmeyer, 2016); that their margin call / liquidation decisions affect market prices (Biais, Heider and Hoerova, 2015; Lorenzoni, 2008) or lead to contagion in incomplete financial networks (Allen and Gale, 2000). Outcomes may also be inefficient due to moral hazard in the case of the "too-big-to-fail" problem whereby private agents free-ride on the government safety net. When such externalities are present, market outcomes can feature excessive leverage (Geanakoplos, 2010; Ranaldo, Rupprecht and Wrampelmeyer, 2016), excessive borrowing ex-ante and liquidation ex-post (Lorenzoni, 2008), or excessive derivatives exposures and too much margining (Biais, Heider and Hoerova, 2015).

These inefficiencies call for macro-prudential regulation to correct the externalities. To stop a crash from happening when bad news hit, leverage may need to be restricted in optimistic times (Geanakoplos, 2010; Ranaldo, Rupprecht and Wrampelmeyer, 2016). To prevent negative externalities of excessive leverage on the ability to borrow in unsecured markets, capital buffers in good times may need to be higher for high-leverage assets than for low-leverage assets (Ranaldo, Rupprecht and Wrampelmeyer, 2016). To prevent excessive borrowing, minimum capitalisation on financial firms needs to be imposed (Lorenzoni, 2008). To prevent excessive margining and eliminate self-fulfilling panics, ex-ante minimum margin/liquidity requirements and/or ex-post margin caps may be needed (Biais, Heider and Hoerova, 2015). For minimum margin requirements and countercyclical variation of margins to be effective, a broad application across products is important, to reduce leakage into products not subject to the regulation (Brumm, Grill, Kubler and Schmedders, 2015). Lastly, central bank asset purchase programs may allow borrowers to reduce illiquid leverage and their exposure to risky securities and thereby increase welfare (Ranaldo, Rupprecht and Wrampelmeyer, 2016).

Regulation that imposes minimum margin requirements increases demand for high-quality liquid assets that are accepted as collateral (Duffie, Scheicher and Vuillemey, 2015). Moreover, it can be costly as holding liquid assets on margin accounts implies foregone return due to not investing in high-yielding riskier assets. Increased demand for high-quality collateral, coupled with potential shortages of liquid assets (as discussed above), calls for mechanisms to optimise the use and management of collateral. One such mechanism that gained on prominence in the aftermath of the financial crisis is Central Clearing Counterparties (CCPs henceforth). We discuss the economics of CCPs and how they may economise on collateral and improve market resilience in the next section.

3.2 Economics of centralised clearing

The process of clearing is a sequence of steps that implement an agreed-upon financial transaction. The clearing process can be bilateral and operated in a decentralized manner, or it can be realised within a single entity, referred to as the CCP. When a transaction is brought to a CCP for clearing, the CCP interposes between contracting parties. For example, in the context of a CDS contract, the original contract between a protection buyer and a protection seller is transformed into two contracts, one between the seller and the CCP and another one between the buyer and the CCP (a process called novation). Importantly, if one of the counterparties is unable to meet its obligations to the other, the clearing entity makes the payment on behalf of the defaulting party.

In this section, we first discuss potential benefits of central clearing compared to decentralised clearing. We then consider how central clearing should be designed to bring about maximum benefits.

Benefits of central clearing

There are several reasons why centralised clearing can be superior to decentralised clearing. The reasons include: 1) mutualisation of counterparty risk; 2) saving on collateral and settlement costs; 3) enhanced transparency; and 4) optimal setting of contracts and margins.

Central clearing allows mutualisation of counterparty risk. Since the CCP interposes itself between a protection buyer and a protection seller, the two counterparties are no longer exposed to each other's default risk. Even if some counterparties default, the CCP can pool resources from those counterparties who do not default and still make transfers that are due, thus providing insurance against counterparty risk (Biais, Heider and Hoerova, 2012). By doing so, central clearing can allow for transactions between parties who do not need to trust each other but only need to trust the resilience and stability of the CCP. The extent to which the CCP can mutualise counterparty risk depends crucially on the CCP's ability to diversify risk. The scope for diversification of counterparty risk is the highest when a single CCP does the clearing as opposed to multiple CCPs (Duffie and Zhu, 2011). Empirical evidence for the CDS market suggests that central clearing reduces counterparty risk as well as systemic risk: it lowers the impact of counterparty credit risk on CDS spreads, consistent with the idea that central clearing helps insulate counterparties from each other's default (Loon and Zhong, 2014).

Central clearing can help save on collateral, by providing netting benefits. When all transactions are novated through a CCP, a clearing member posts collateral to covers his net exposure vis-a-vis a CCP, instead of posting collateral for each individual transaction. This can economise on the use of collateral and enhance efficiency when posting margins is costly. Moreover, by transforming bilateral exposures into multilateral ones, a CCP can defer settlement and hence economise on settlement-related costs (Koeppl, Monnet, and Temzelides, 2012).

Whether central clearing brings about improved netting efficiency depends, however, on how many asset classes are centrally cleared and how many CCPs do the clearing (Duffie and Zhu, 2011). When a CCP is introduced for a particular asset class while keeping other asset classes uncleared, it brings about opportunities for multilateral netting within that asset class but it also leads to a loss of bilateral netting between counterparties across different underlying assets. In this case, the

introduction of a CCP is beneficial only if the opportunity for multilateral netting in the cleared asset class dominates the resulting loss in bilateral netting opportunities across uncleared asset classes. Trading network structure and trader's risk aversion also affects the netting efficiency of central clearing (Garratt and Zimmermann, 2015). Central clearing is less likely to be beneficial for networks where a large number of asset classes are traded by a small number of dealers. At the same time, central clearing may reduce the variance of the net exposures between counterparties, which is beneficial if counterparties have some degree of risk aversion. Empirical evidence suggests that central clearing of CDS transactions does reduce system-wide collateral requirements, provided there is no significant proliferation of CCPs (Duffie, Scheicher and Vuillemey, 2015). The reduction in collateral requirements can be significant. For example, Heller and Vause (2012) estimate that initial margin requirements required by a single CCP that clears all asset classes would be only 74% of those demanded by separate CCPs for each asset class.

Central clearing enhances transparency. Detailed information about risks and risk exposures involved in a transaction are key to designing optimal financial contracts. Centralised clearing can ensure that relevant information is available to clearing members. This can eliminate contractual externalities among counterparties (Acharya and Bisin, 2014) and prevent that counterparties enter into excessive contracts (Leitner, 2012). Empirical evidence suggests that increased post-trade transparency due to central clearing is associated with an improvement in CDS liquidity and trading activity (Loon and Zhong, 2014).

Central clearing counterparties should enhance efficiency in setting margin requirements. As discussed in the previous section, margin calls can trigger asset sales and adversely affect asset prices through a fire-sale mechanism. Individual counterparties take asset prices as given when setting margin requirements. This can lead to excessive margining in financial contracts compared to contracting which internalises potential adverse price effects (Biais, Heider and Hoerova, 2015). CCPs are large players who could take into account their impact on financial markets and thus mitigate fire-sale externalities. Moreover, by setting standardised margin requirements and enforcing them, CCPs can prevent bilateral disputes between counterparties concerning margin setting.

Optimally designed central clearing must take into account interactions between various risk-management elements. For example, since both mutualisation and margins provide insurance against counterparty risk, central clearing may allow contracting parties to put up lower margins compared to bilaterally settled contracts. However, since margins not only provide resources in the event of counterparty default but also provide incentives to avoid counterparty risk, the CCP should still set sufficiently high margin requirements to reduce counterparty risk it faces.

In sum, central clearing can help reduce counterparty and systemic risk compared to the bilaterally cleared transactions (for more evidence on this as well as the role of transparency and regulation, see Box A). At the same time, it is important to bear in mind that central clearing does not eliminate risks in financial contracting. Instead, it re-allocates risk from contracting parties to the CCP as the CCP interposes between counterparties, and concentrates large amounts of risk in a single entity (or a few big entities). Such re-allocation of risk may by itself alter incentives of contracting parties. Furthermore, the concentration of risk makes CCPs systemically important institutions which may affect incentives of CCPs for prudent behaviour. Also, greater use of CCPs means greater reliance on a limited range of risk-management practices, which may synchronise reactions to shocks and have

pro-cyclical effects on financial markets and financial system at large. We discuss next some issues affecting the effectiveness of the central clearing process.

Box A – The resilience of short-term debt markets: the role of collateral and clearing agents

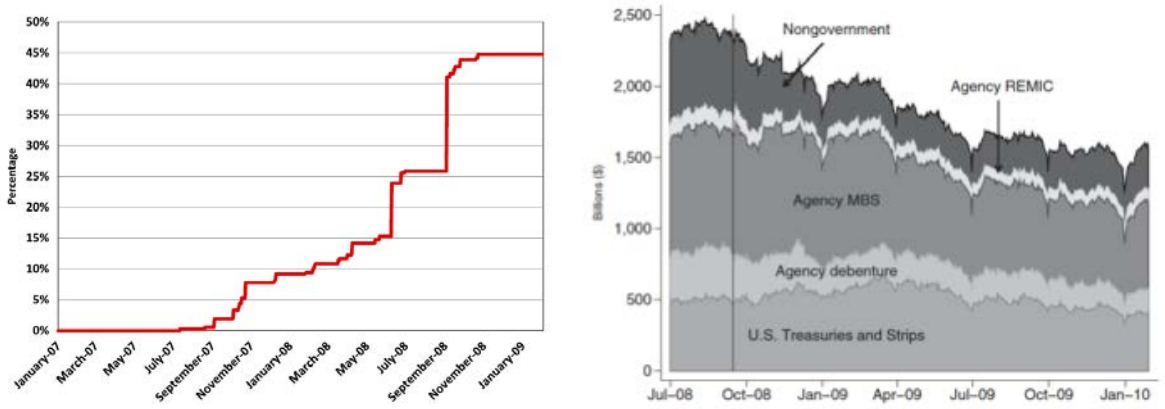
Using collateral is neither a sufficient nor a necessary condition for the resilience of short-term debt markets. Other factors such as the existence of market infrastructures, clearing agents, transparency and sound supervision matter too.

Compare, for example, bi-lateral and tri-party repo markets. In a bi-lateral repo market, a borrower and lender negotiate and clear the repo directly. In a tri-party repo market a third party clears the repo, i.e., the third party manages the flow of cash and collateral between borrowers and lenders. The presence of a clearing bank changes the nature of the transaction as it interposes between a borrower and a lender in the same way a CCP does.

The empirical evidence shows that the presence of a clearing agent improves market resilience. The bi-lateral repo market in the U.S. froze as haircuts rose very quickly for collateral assets that were not of the highest quality, i.e., Treasuries (see Figure A.1: Panel A). The volume of trading in the tri-party market, however, remained stable throughout the financial crisis.

Figure A.1: Resilience of bi-lateral and tri-party repo markets in the U.S.

Panel A: Bi-lateral market (haircuts, percent) **Panel B: Tri-party market (trading volume, USD bn)**



Note: Panel A: Haircuts on assets other than Treasuries.
Source: Panel A: Gorton and Metrick (2012). Panel B: Copeland et al. (2014)

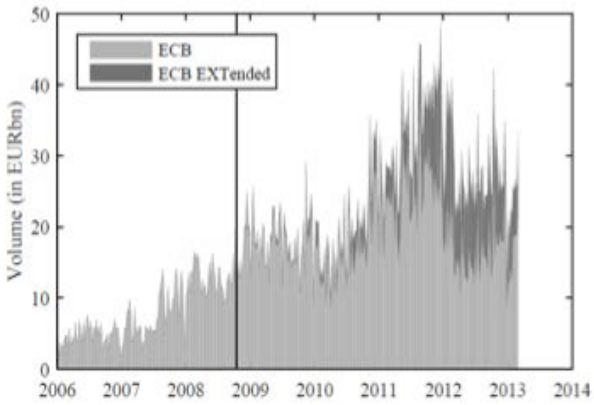
When a third party serves as a clearing agent, the asset serving as collateral tends to be no longer specific. Instead, the asset only has to belong to a certain pool of assets, say government bonds with a certain rating. Haircuts also tend to be no longer transaction specific but are set for all transactions between a borrower-lender pair. Accordingly, there is little variation in haircuts and rates for tri-party repos (see Krishnamurthy et al., 2014; Copeland at al., 2014; and Hu et al, 2015).

The importance of clearing and high-quality collateral for market resilience is also seen in euro area repo markets. In fact, activity in those markets increases in times of stress (Figure A.2: Panel A).

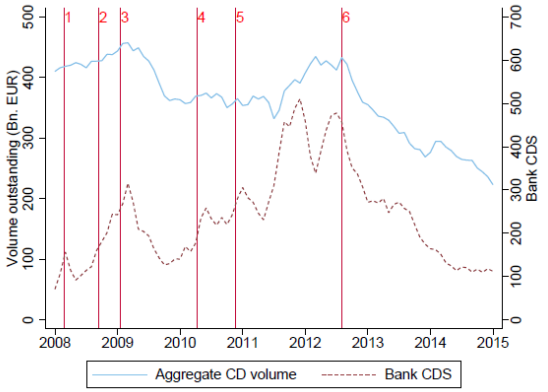
Surprisingly, similar market resilience in times of stress can also be achieved in unsecured markets. The distinguishing feature of resilience without collateral and without clearing appears to be a level of transparency as well as stringent market regulation and supervision. Activity on the largest market for banks' certificates of deposits, i.e., the French TCN (titres de créances négotiables) market, increases whenever banks' CDS spreads increase (Figure A.2: Panel B). This market is supervised by the Banque de France, which requires market participants to file extensive documentation and publishes detailed information about issuance activity.

Figure A.2: Resilience of secured and unsecured markets in the euro area

Panel A: Cleared repo market (trading volume, EUR bn)



Panel B: Unsecured but supervised market (outstanding volume, EUR bn)



Note: Panel A: The market is the repo market cleared on Eurex. ECB extended refers to the extended GC pooling set of collateral assets. Panel B: The market is the French market for bank certificated of deposits supervised by the Banque de France (titres de créances négotiables). The blue line refers to the outstanding volume, the red dashed line refers to the 5-year CDS spreads of the banks active in the market. The red vertical lines refer to market events (see Pérignon et al., 2017, for details).

Source: Panel A: Mancini et al (2015). Panel B: Pérignon et al. (2017)

Issues in the central clearing design

The re-allocation of risk to the CCP may alter incentives of contracting parties. For example, CCPs can provide insurance against counterparty risk. Due to such insurance, counterparties may choose to take on more risk than they would otherwise, that is, there may be moral hazard due to CCP insurance. Therefore, to ensure that CCPs do not face excessive risks, CCPs must be designed to preserve incentives for prudent risk-management by their counterparties. Ultimately, the CCP is as strong as are its members collectively.

To cope with the risks it faces, the CCP imposes margin requirements for cleared transactions, and maintains capital and liquid reserves. The CCP can issue equity capital subscribed to by the brokers and financial institutions using its services. The reserves can be built up by levying a fee on the clearing members (possibly contingent on activity levels). In case one or more clearing members default, rules are in place which specify the financial safeguards available to a CCP to cover losses and the order in which resources would be expended, as well as what happens following the exhaustion of all such safeguards. Recent empirical evidence underscores the importance of well-defined loss-sharing rules for the ability of a CCP to reduce risk. Boissel, Derrien, Örs, and Thesmar (2015) document that the centrally-cleared European repo market showed signs of stress in the height of the euro area sovereign debt crisis: repo rates in CCP-based trades were as sensitive to sovereign CDS spreads as repo rates in bilateral trades, suggesting that investors perceived the probability of a CCP failure conditional on sovereign default to be similar to counterparty risk in bilateral transactions. This may be attributed to unclear loss-sharing rules among CCP members in case of default.

CCPs should design and enforce risk-management practices that provide incentives for their counterparties to manage risk prudently. Otherwise, counterparties may have incentives to free-ride on counterparty risk insurance provided by the CCP, and avoid undertaking costly actions that reduce counterparty default risk. For example, CCPs should set margining rules. Leaving counterparties to design their own margining practices could lead to insufficient margining and excessive counterparty default that would be borne by the CCP (Biais, Heider and Hoerova, 2016).

CCPs risk-management practices should be robust to market stress, and CCPs clearing multiple asset classes must be mindful of changing correlations among the exposures at times of market turbulence. At the same time, CCPs must ensure that their margining practices do not over-react to market stress and do not worsen liquidity and volatility in financial markets. In particular, value-at-risk margin models – which are widely used for risk-assessment when setting initial margins - were shown to lead to overly pro-cyclical margins, with margins increasing fast following volatility spikes (Park and Abruzzo, 2016). The potentially large impact of pro-cyclical CCP margining practices on financial markets suggest that CCPs should disclose the pro-cyclicality properties of their margin models to market participants to help them anticipate potential margin calls as well as to regulators to enable assessment whether the margining practices are not excessively pro-cyclical (Murphy, Vasios and Vause, 2014, 2016).

Providing appropriate risk mitigation may, however, interfere with the objective of making a profit for a CCP. For example, if a CCP provides full insurance against counterparty risk, such insurance may undermine counterparties' incentives to perform costly due diligence and find solid counterparties (Biais, Heider and Hoerova, 2012). In turn, this increases the overall rate of counterparty failure that

a CCP is exposed to. A for-profit CCP that is protected by limited liability may not internalise the cost of excessive counterparty failure. It may therefore offer full insurance and charge a high clearing fee to maximise its profits in states in which it does not default.

Governance of CCPs is key in ensuring that CCPs and their clearing members have incentives to follow prudent risk-management practices. One way to provide such incentives is to structure a CCP as a cooperative or mutual, whose users are its owners. Liability for potential losses incurred by a CCP would make its members averse to risk-taking by the CCP. A potential downside is that cooperatives are often limited in scope and scale, and a for-profit CCP owned by external shareholders can be more efficient.

Due to economies of scale in CCP business, a CCP may become a systemically relevant and too-big-to-fail institution. Indeed, reaping the benefits of diversification and collateral netting calls for a (single) CCP to clear a large number of transactions. However, a potential failure of such CCP could then affect many counterparties and propagate throughout the financial system. To prevent such propagation and contagion, a government intervention to prevent a CCP failure can be warranted. Anticipation of a government rescue in bad states leads to potentially diverging social and CCP incentives due to a moral hazard problem at the CCP level.

Diverging private and social incentives call for stringent regulation and supervision of CCP activities. Regulators and supervisors must monitor CCP activities and make sure that adequate risk management practices are in place. Proper risk management practices for CCPs include optimally designed contracts, membership rules, and sufficient liquidity buffers and loss-absorption capacity (through equity capital, default fund and margins). Given the global nature of financial transactions, it is important to ensure globally consistent standards and avoid potential for regulatory arbitrage. There should also be resolution mechanisms for CCPs in place which make sure that CCP positions are unwound in an orderly manner in case of failure.

To mitigate the too-big-to-fail problem, a large CCP can be split in several smaller entities but such splitting will come at the cost of reduced efficiency. Smaller CCPs would be incentivised to exercise prudent risk management practices by the fear of default. However, splitting the CCP in several entities could come at some costs. First, mutualisation benefits would decrease by reducing the economies of scale inherent in the pooling of risks. This is akin to the inefficiency of splitting natural monopolies. It may also entail the risk that the optimal amount of the public good in question (clearing) is ultimately not provided. Second, splitting CCPs could also increase the cost of collateralisation. Third, competition between several CCPs might lead to a race to the bottom in terms of risk management standards. CCPs may want to loosen risk management standards to gain market share. For example, Park and Abruzzo (2016) document that margin setting of CCPs may reflect competitive pressures, with a CCP lowering (raising) its margins when it has higher (lower) margin levels than its important competitor.

Interoperability between CCPs could help mitigate some of the downsides of splitting the CCP in several entities. For example, CCPs can use cross-margining, allowing clearing members to use their positions at different CCPs to lower collateral requirements. Furthermore, CCPs can employ linked arrangements, enabling their members to clear trades from multiple venues.

Interoperability between CCPs enables CCPs to observe positions that their counterparties hold with other CCPs. This is key for CCPs to be able to set margin requirements correctly. For example, in the markets with limited liquidity, margin setting needs to take into account that liquidating large positions of a defaulting counterparty can be very costly. Therefore, margin requirements need to increase disproportionately in the position size. However, such margin requirements create an incentive for counterparties to split their positions across multiple CCPs, effectively "hiding" potential liquidation costs from each CCP (Glasserman, Moallemi and Yuan, 2015). In the absence of interoperability, each CCP would need to set higher margin requirements to protect itself again hidden liquidation costs compared to a CCP that could set margins conditioning on a counterparty's total position size.

Interlinking CCPs is a complex process, which may involve different jurisdictions and regulatory regimes, bringing about its own set of operational, legal and counterparty risks. In this respect, reaping the benefits from competition requires regulatory coordination, strict (international) standard setting and enforcement.

4. Central bank operations and collateral markets

This section highlights the interrelationship between central bank operations and markets for collateral. Central bank operations can alter the mix of assets available for use by private market participants. For example, a central bank that is providing liquidity to the financial system will typically either take collateral or purchase assets outright – so that, in either case, the central bank liquidity provided may be partly offset by a reduction in the stock of assets available for use as collateral in private transactions, such as repos.

A recent BIS working paper (CGFS (2015)) highlights how central bank actions can impact collateral markets mainly through a scarcity and a structural channel. Structural effects mainly include effects from the designation of eligible securities. A decision to accept a type of asset as collateral in a central bank operation will affect its pledgeability, inducing an increased willingness from issuers to issue these assets and from counterparties to hold them on the balance sheet. The two channels may also interact. For example, structural effects might tend to induce scarcity effects by influencing the collateral services provided by a given stock of collateral assets.

Scarcity effects result from the impact of central bank operations on the prices (or yields) of collateral assets. Such price changes may arise from changes in the availability of collateral and/or the collateral composition of the market. Collateral availability can be increased or decreased depending on whether central bank operations are collateral absorbing (outright purchases and repos or secured loans) or collateral providing (outright sales, reverse repo and issuance of central bank instruments). Pure changes in collateral composition result from operations that adjust the quality of available collateral in the market (collateral upgrade vs collateral downgrade).

The section is structured in two subsections with a particular emphasis on the Eurosystem operational framework. The first focuses on the interplay between the traditional open market operations and collateral markets, while the second subsection discusses how outright purchases by a central bank can affect collateral markets. The section mainly focuses on empirical studies that document the scarcity and structural channel.

4.1 Eurosystem open market operations and collateral markets

This subsection focuses on operations that involve the exchange of collateral assets against central banks reserves. These operations are characterized by several features such as i) eligibility policy defining the range of securities that can posted as collateral with the central bank; ii) haircuts applied by the central bank; iii) valuation of securities that do not have a reliable market price and iv) operational parameters such as size and term of the transactions.

The designation of which securities are eligible collateral for borrowing from the central bank is expected to have both structural and scarcity effects on collateral markets. Structurally, assets tend to become more pledgeable per unit among private investors if they are eligible as collateral at the central bank. This structural effect on the value of a collateral asset that is designated as central bank-eligible is likely to be borne out even if there is no outstanding borrowing at the central bank

using this asset as collateral or if the holder cannot access a central bank's liquidity facilities. Thus, securities that become eligible should demand an eligibility premium that represents the increased desirability of the asset due to possibility to pledge the asset itself with the central bank. Therefore, the eligibility of a marketable asset should have a positive effect on its market price via a scarcity channel. Such effects should be stronger in periods of liquidity crises, when a central bank is more likely to enlarge the group of securities that are eligible as collateral for borrowing from its facilities. All other things being equal, the price of newly eligible securities should go up, owing to the improved ability of financial institutions to borrow against them. Box B provides recent evidence that changes in the Eurosystem eligibility criteria had a positive price impact on targeted securities during the financial and euro area sovereign debt crisis.

Central bank eligibility may give rise to structural effects inducing market participants to structure assets to meet central bank eligibility criteria. The introduction of Asset Backed Securities (ABS) transparency requirements has had structural effects on collateral issuance patterns, based on changes in the documentation of newly issued ABS in order to comply with these requirements and to ensure that they meet central bank eligibility requirements. An example is the Eurosystem ABS loan level initiative, which was aimed at improving transparency in ABS markets by requiring loan-by-loan information to be made available to market participants and facilitating the risk assessment of these securities when used as collateral by Eurosystem counterparties in monetary policy operations (CGFS (2013)).[21] There is also some evidence from discussions with market participants that institutional investors use assets' central bank eligibility as a broad quality benchmark (CGFS (2013)). Overall, this suggests that eligibility can have important structural effects creating the incentives for issuing central bank-eligible assets and highlights the possible role of central banks as standard setters in securities markets.

Central bank eligibility/usability might also induce market participants to issue own assets for the sole purpose of being retained and pledged as collateral. Carpinelli and Crosignani (2016) provide an example of how the possibility of a bank of using own-name assets (i.e. assets issued, originated or guaranteed by the bank itself) might impact the amounts issued more than market prices, as securities can be issued for the sole purpose of being pledged as collateral. They exploit a regulatory intervention approved by the Italian government on the day after the first allotment of the 3-year Long Term Refinancing Operations (LTROs), when the Eurosystem offered three-year collateralized liquidity. The intervention allowed banks to obtain, for a fee, a government guarantee that induced banks to manufacture eligible collateral for the Eurosystem liquidity operations. After the introduction of the scheme by the Italian government, Italian banks created and pledged 69 billion euros worth of new collateral at the second allotment of 3-year LTRO, corresponding to a third of total uptakes. Therefore, how assets can be pledged in central bank operations can also influence the underlying market. In response to these developments, the Eurosystem decided to phase-out the possibility of own-use for issued government guaranteed bank bonds as of 1 March 2015.[22]

As previously mentioned the eligibility of a marketable asset should also have a positive effect on its market price via a scarcity channel. So far, there is limited empirical evidence on the impact of central bank eligibility on asset prices. Ashcraft, Gârleanu, and Pedersen (2011) present evidence

[21] See https://www.ecb.europa.eu/paym/coll/loanlevel/html/index.en.html.
[22] See https://www.ecb.europa.eu/press/pr/date/2013/html/pr130322.en.html.

regarding the effects of Fed lending under the Term Asset-Backed Securities Loan Facility (TALF). Their evidence indicates that TALF lending did affect the prices of assets that became eligible for use as collateral for borrowing under this programme but the impact is limited and temporary. They look at the differential effect on commercial mortgage-backed securities (CMBS) that were eligible for the TALF programme relative to the effect on similar securities that were not eligible. They measure a temporary decrease of 5 basis points in the yield for the eligible TALF securities, but a statistically significant rise in the yield by over 20 basis points for the non-eligible assets during the first two weeks of the programme. Similarly, Campbell et al. (2011) find that TALF lowered interest rate spreads for some categories of asset-backed securities (ABS) but had little impact on the pricing of individual securities.

Recent research finds that changes in the Eurosystem eligibility criteria had a price impact. On 15 October 2008 the ECB announced that USD-denominated bonds were admitted as eligible collateral subject to the fulfilment of the relevant eligibility criteria from 14 November 2008 to until the end of 2009, which was later extended until 31 December 2010. One key eligibility criterion is that USD-denominated bonds have to be deposited in the European Economic Area (EEA) to be eligible collateral for the ECB operations. Corradin and Rodriguez-Moreno (2016) find that a substantial number of the USD-denominated bonds issued by euro area countries could not benefit from this temporary acceptance due to the non-fulfilment of this criterion. They find that the changes in Eurosystem eligibility criteria lowered the yield-to-maturity of the eligible relative to the non-eligible USD-denominated bond by 13 basis points (see Box B). In addition, the impact is more persistent and lasting (more than eight weeks) than the overall impact measured by Ashcraft, Gârleanu, and Pedersen (2011). Overall, their findings support the idea that the possibility of being pledged to the Eurosystem in exchange for liquidity is priced via a scarcity channel affecting the collateral value of the asset itself.

The haircut policy of a central bank, together with its assessment of the underlying credit quality of eligible collateral, is one of the key dimensions of its operations in collateral markets. Central bank haircuts tend to impact collateral markets through the structural channel, by changing the degree of pledgeability of a collateral asset, and the scarcity channel, by changing asset prices.

Higher haircuts may lead to substitution effects by incentivising counterparties to post other types of collateral via a structural channel. One particularly interesting piece of empirical evidence on the effects of changes to a central bank's haircut policies on collateral markets is the application of the Eurosystem's increase in haircuts to "additional credit claims" (ACCs). The ACC framework was introduced by the Eurosystem in December 2011 as a temporary measure to allow credit claims, such as pools of residential mortgages, to be eligible (Tamura and Tabakis (2013)). In June 2012, haircuts for some types of ACCs were significantly increased and the use of these ACCs types in the Eurosystem operations substantially decreased due to their relatively reduced attractiveness as a collateral asset (CGFS (2015)) .

Box B – Eurosystem eligibility of foreign currency-denominated assets

The Eurosystem used to accept collateral denominated in euros before the Great Financial crisis. However, on two occasions, in October 2008 (until December 2010) and again in September 2012, the collateral framework was temporarily extended to include certain debt instruments denominated in US dollar, pounds sterling and Japanese yen.

This box is based on the empirical findings of Corradin and Moreno-Rodriguez (2016) and examines the price effect of such changes on the affected assets by estimating the yield reaction around the announcement and the introduction of the collateral extension. The relative pricing of comparable pairs of USD- and EUR-denominated bonds issued by the same euro area country is used. A basis is computed as the difference between the yield-to-maturity of a USD-denominated bond, after hedging the foreign exchange rate risk, and the yield-to-maturity of a comparable EUR-denominated bond. Due to data availability, the basis is computed for pairs issued by the governments of Austria, Belgium, Finland, Italy and Spain.

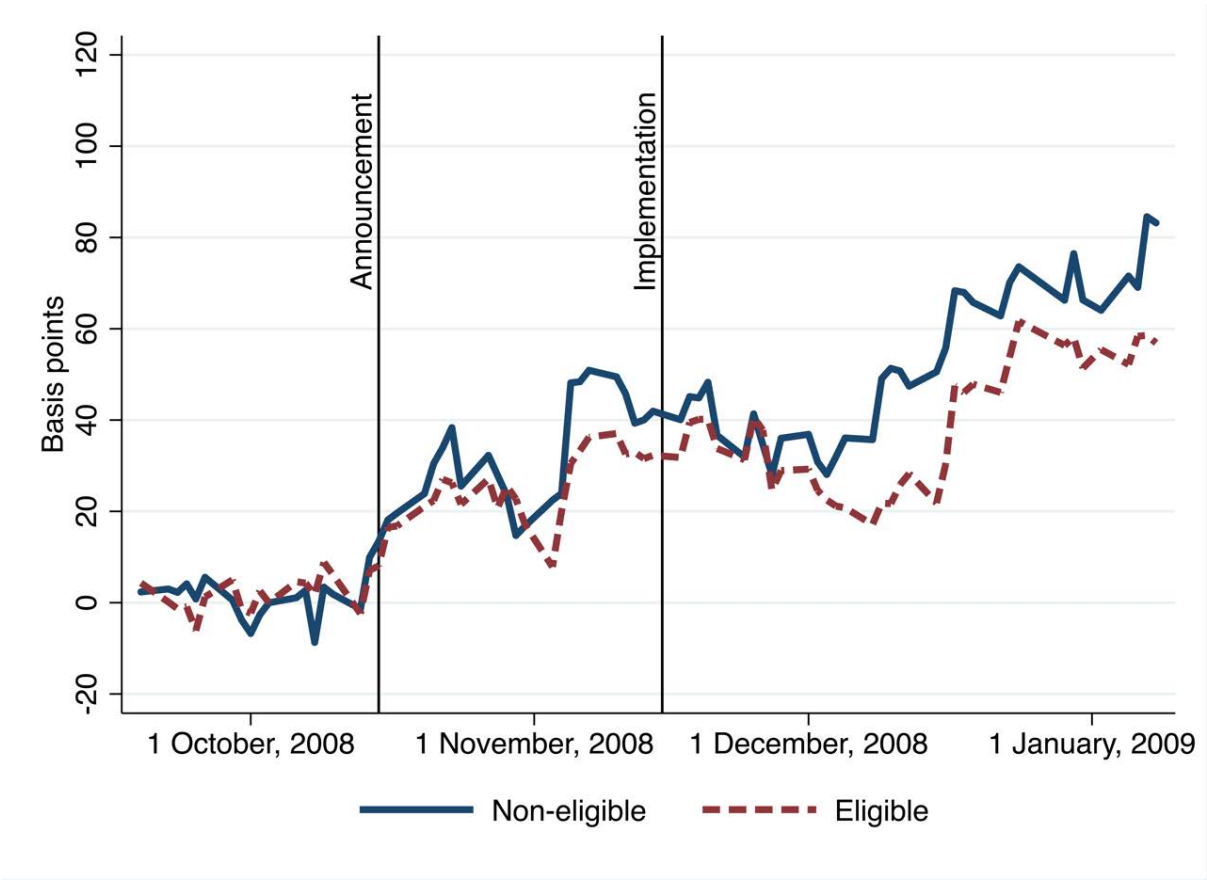
To establish a link between Eurosystem eligibility criteria and yields, the following identification strategy is used. Almost half of the USD-denominated bonds in the sample did not benefit from the temporary expansion of the collateral, because they did not satisfy the depository requirement in the European Economic Area (EEA) making them ineligible for the Eurosystem liquidity operations. For example, this requirement is not generally met by USD-denominated bonds issued under the New York law. Instead, the other half of the USD-denominated bonds in the sample became eligible for the Eurosystem liquidity operations. Such feature of the programme allows to assess whether the price (or yield) of an eligible USD-denominated bond increased (or decreased) relative to a non-eligible USD-denominated bond issued by the same euro area country.

Figure B.1 shows the estimated response of the basis around the introduction of the changes in the eligibility criteria on 14 November 2008. It plots the averages for the eligible US dollar-denominated group of bonds (red dashed line) and the non-eligible US dollar-denominated group of bonds (blue line) minus their respective pre-announcement average over time. There are two main conclusions to be drawn from the figure. First, the basis grows strikingly large and positive over time: US dollar-denominated bonds are traded at a lower price (or higher yield) than euro-denominated bonds. But before the announcement, eligible and non-eligible bonds have similar basis levels. Second, after the announcement, the eligible bonds have a basis that is 13 points lower on average than that of ineligible bonds.

The average change in the basis can be interpreted as an "eligibility premium". Eligible USD-denominated bonds were subject to an additional haircut of 8% due to the denomination in the USD currency. In Corradin and Rodriguez-Moreno's (2016) sample, the EUR-denominated bond is on average subject to a 3% haircut. Thus, a comparable USD-denominated bond is subject to an overall haircut of 10.76% = 1 -(1-3%)x(1-8%). As a result, the estimates suggest that the change in the

Eurosystem eligibility criteria lowered the yield-to-maturity of the eligible USD-denominated bond, after hedging the currency risk, by 13 basis points by decreasing haircuts from 100% to 10.76%.[23]

Figure B.1: Eurosystem collateral eligibility expansion: yield impact on affected assets



Note: The figure plots the averages for the eligible US dollar-denominated group (red dashed line) and the non-eligible US dollar-denominated group (blue line) minus the respective pre-announcement average.

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[23] The analysis is also carried over around the second change in the collateral eligibility criteria (September 2012). The impact is still persistent and significant, although the overall impact is lower. After the implementation of the second extension the eligible pairs have on average a lower basis of 7 basis points.

A change in haircuts can also have scarcity effects. The larger the haircut on an asset, the more of the asset the counterparty has to provide to the central bank in order to collateralise a given amount of borrowing, thereby reducing the quantity of the collateral available to generate funding in private markets. Corradin and Rodriguez-Moreno (2016) study the impact of positive and negative changes in the Eurosystem haircuts policy on bonds issued by sovereign agencies. They compare the yield-to-maturity of the sovereign agency bond to the yield-to-maturity of a comparable bond issued by the same sovereign. Sovereign agency bonds that are eligible Eurosystem collateral are subject to higher haircuts than comparable EUR-denominated sovereign bonds. However, the sovereign agency bond is explicitly or implicitly guaranteed by its own sovereign country making the two bonds very similar from a risk point of view. They document that increases in the difference between the agency and the sovereign haircuts applied by the Eurosystem significantly increase (decrease) the yield (price) of the sovereign agency bond. On the other hand, decreases in the haircuts differences do not provide a conclusive impact on the yield. Thus, their evidence suggests that the market response is more sensitive to increases than decreases in the haircuts because the first ones might reduce the liquidity that banks can withdraw from the Eurosystem. As a consequence, this would affect the collateral value of the asset.

A key determinant of the influence of central bank haircut schedules on collateral markets is how they interact with the haircut schedules set by CCPs and private repo markets. In fact, assets might be subject to central bank and CCPs haircuts and large differences between the two might lead to violations of the law of one price. The absence of arbitrage opportunities is a central tenet of asset pricing theory: assets that generate identical cash flows must command the same market price, so that there is no opportunity for profitable arbitrage trading ("The Law of One Price" - LoOP). Gârleanu and Pedersen (2011) highlight that during a liquidity crisis the limited ability of financial institutions to borrow against their securities due to funding constraints can lead to violations of the LoOP. In such circumstances, actions by the central bank can increase asset prices by keeping haircut requirements lower than the private ones and offering loans. This improves the funding condition of the financial sector and, importantly, makes the affected assets more attractive than they would be otherwise (Ashcraft, Gârleanu , and Pedersen (2011)).

However, haircut differences for securities with (nearly) identical cash flows may lead to basis or price gaps during a liquidity crisis. Corradin and Rodriguez-Moreno (2016) document that increases in haircuts on Italian and Spanish EUR-denominated bonds by CCPs in the fall of 2011 led to larger yield deviations between USD- and EUR-denominated bonds issued by the same countries in periods when the Eurosystem kept haircuts substantially lower and stable but only for EUR-denominated bonds. Because of the differences in haircuts between the CCPs and the ECB proxies for the opportunity cost a bank faces with the choice of demanding liquidity in the refinancing operations of the Eurosystem and in the centrally cleared private repo markets, increases in the CCPs haircuts tend to reduce asset values, make refinancing more costly in the private repo markets, as also shown by Gromb and Vayanos (2002) and Brunnermeier and Pedersen (2009) and documented empirically by Gorton and Metrick (2012) and Krishnamurthy, Nagel, and Orlov (2014), and induce banks to rely more on central bank liquidity. In such circumstances, the wealth of some agents in the economy falls and borrowing constraints are more likely to bind, inducing a widening of the basis or yield gap as predicted by Gârleanu and Pedersen (2011). Thus, the fact that only EUR-denominated bonds could be pledged in exchange for Eurosystem liquidity in the fall of 2011 generates a stronger asymmetry between USD- and EUR-denominated bonds and leads to larger deviations.

Increases in CCPs haircuts might also affect the central bank balance sheet in terms of collateral composition and banks' liquidity needs. Box C evaluates the extent to which the dramatic rise in haircuts on Italian sovereign bonds by LCH Clearnet on 9 November 2011 had an impact on the Eurosystem collateral and liquidity balance sheet. The Box documents that some Eurosystem counterparties were affected by the increase in haircuts more heavily than others. As a result, these affected institutions increased substantially the amount of Italian sovereign bonds which they pledged to the Eurosystem – whose haircuts on sovereign bonds remained practically unchanged –, as well as the liquidity withdrawal from the Eurosystem liquidity facilities.

In addition to eligibility and haircuts, the operational terms of transactions, such as the size of operations and the maturity term of the transactions might play a key role in affecting collateral markets through the scarcity and structural channel. Since central bank operations are effectively asset swaps, the impact of these swaps depends on their size and maturity term. The maturity term determines how long the collateral will remain encumbered at the central bank, potentially inducing scarcity. But encumbrance is also affected by the scale of central bank operations. The greater the scale of the operation, the more collateral can become encumbered at the central bank adding to any scarcity effect.

Recent research documents the impact of the Eurosystem 3-year LTROs conducted in December 2011 and February 2012 on the sovereign term structure and debt issuance. Crosignani et al. (2016) analyse the impact of this unconventional monetary policy operation on the demand for Portuguese government debt. They find that Portuguese banks significantly increased their holdings of domestic government bonds after the announcement of this policy. This increase in holdings was tilted towards shorter maturities, with banks rebalancing their sovereign debt portfolios towards shorter term bonds engaging in a "collateral trade", which involved the purchase of high yield bonds with maturities shorter than the central bank borrowing in order to mitigate funding liquidity risk. By investing in bonds with a maturity shorter than three years, those assets mature before the liquidity provided via the Eurosystem reverse operation is due. On the other hand, longer term bonds expose the bank to the risk that their prices may be lower by the time the loan matures. They document that the yield curve for the Portuguese sovereign steepened after the announcement of the 3-year LTROs due to the pressure of banks' purchases of short-term government debt (scarcity channel) and that the government adjusted the composition of its bond issuance accordingly (structural channel). Overall, their results suggest that the largest liquidity operation ever conducted by a central bank had a substantial impact on sovereign borrowing costs and affected the government debt portfolio holdings of financial intermediaries.

Box C – Impact of CCPs haircuts on the Eurosystem collateral and liquidity balance sheet

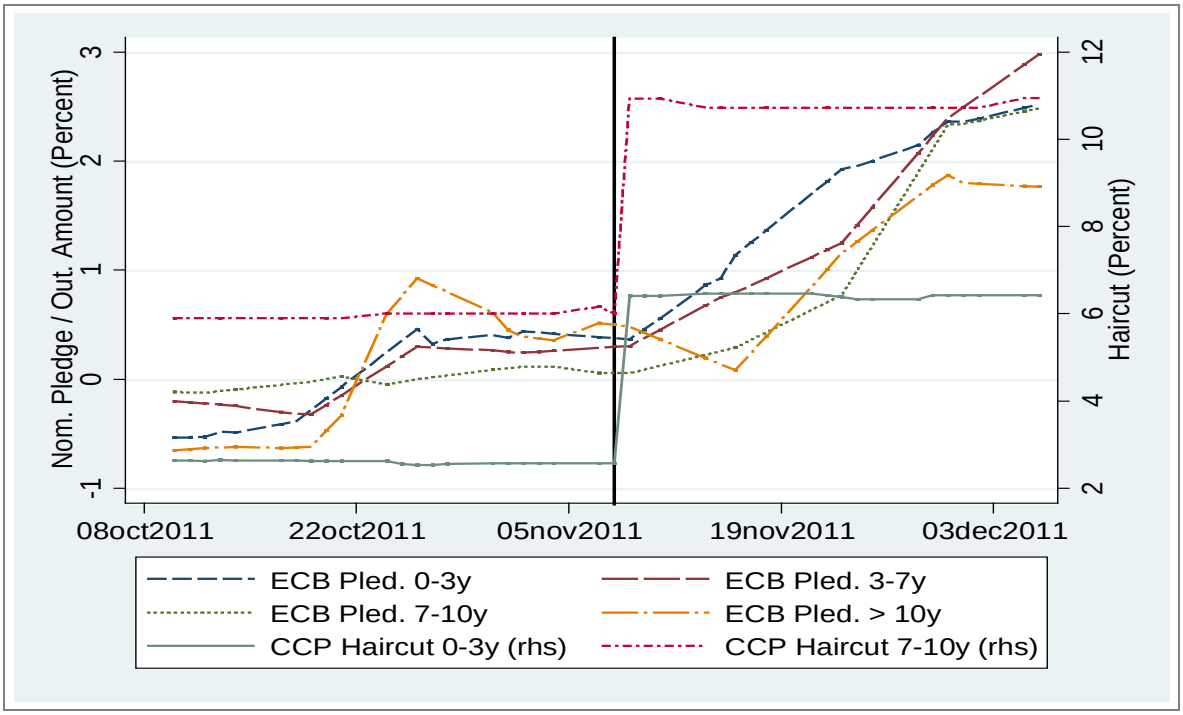
In the aftermath of the tensions on the Italian sovereign bond market in Autumn 2011, Central Counterparty (CCP) clearinghouses – notably LCH Clearnet SA and Cassa di Compensazione e Garanzia (CC&G) – significantly increased the haircuts they required on repo transactions collateralised by Italian sovereign bonds from 300 bps in June 2011 to above 800 bps on 9 November 2011. This box focusses on the short period of time around the change in haircuts, and on the reaction of the Eurosystem balance sheet over a "pre-event" window of 4 weeks before (7 October – 8 November 2011) and "post-event" window of 4 weeks after (10 November - 6 December 2011) 9 November 2011.

According to their internal rules, the LCH Clearnet raised haircut requirements once the spreads of the 10-year bonds (relative to the AAA euro area sovereign issuers' benchmark) were above 450 bps. In November 2011 Italian sovereign bond yields hit this threshold.[24] *The increase in the haircuts for the Italian government bonds requested by LCH Clearnet substantially penalised the shorter maturities.*[25] *After the announcement on 8 December 2011 of the two 3-year longer-term refinancing operations (LTRO), the CCPs decreased their haircut requirements. While in autumn 2011 the haircuts charged by CCPs mounted substantially, the average haircuts charged by the Eurosystem to its counterparties pledging Italian sovereign bonds remained approximately constant and did not exceed 200 bps.*

Banks increased the volume of Italian bonds pledged to the Eurosystem; these bonds were the very same bonds on which private repo haircuts increased. Figure C.1 depicts a breakdown by maturity buckets of the Italian government bonds pledged to the Eurosystem in the four weeks around 9 November 2011, when CCPs raised their haircuts requirements. The dashed red line on the figure shows the jump in the average haircut/margin at that time. Nominal amounts pledged by maturity buckets are expressed as a percentage of the outstanding amount and have been de-meaned by their respective pre-event (7 October – 8 November 2011) averages. The increase in bond pledged is highest for the 0-3 year and the 3-7 year maturity buckets during the post-event window, 2.24% and 2.58% respectively. The increase is also significant for higher maturity: the 7-10 year bucket goes up by 2.47%, while the bucket with maturity of 10 year and above goes up by 1.26% (after declining initially). Since the increase of haircut requirements shifted up the whole term structure by about 500 bps on average across maturities, the haircut requirements must have increased proportionately more for bonds with short-term maturity than for bonds with long-term maturity.

[24] The Spanish sovereign spread hit the threshold in November 2011 as well, while this had already happened earlier to Greece (May 2010), Ireland (November 2010), and Portugal (April 2011).
[25] The 1-3 month class haircut increased from 1% to 4.50% (350% increase), while the 7-10 year class haircut went up from 6.65% to 11.65% (75% increase).

Figure C.1: LCH Clearnet Haircuts and decomposition of Italian sovereign debt pledged by maturity buckets



Note: The figure depicts a breakdown by maturity buckets (in years) of Italian sovereign debt pledged to the Eurosystem, de-meaned by their respective pre-event averages and the evolution of average haircuts applied to Italian sovereign bonds by LCH Clearnet SA and CC&G for the 0-3 year and 7-10 year maturity buckets. The vertical line refers to the increase in the haircuts by LCH Clearnet and CC&G (9 November 2011).

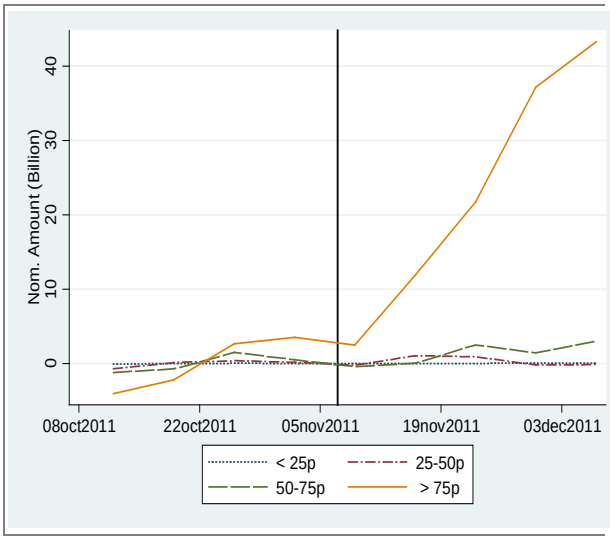
The Eurosystem picked up the slack. Figure C.2 panel (a) presents the evolution of the total nominal amount of Italian sovereign bonds pledged to the Eurosystem by four groups of European banks, classified according to the nominal amount of Italian bonds they pledged at the end of the event-window (6 December 2011).[26] *The figure shows that only one group of banks, the top quartile, dramatically increased the amount of Italian sovereigns pledged after the jump in haircuts. Moreover, this group that pledged most was not different from the other ones before the jump in haircuts. For those banks, which presumably were the most reliant on Italian bonds to fund themselves, the pledging of Italian sovereign bonds rose by 43 EUR billions. Figure C.2 panel (b) reports the total liquidity withdrawn by the same four groups in long term refinancing operations (LTROs) and main refinancing operations (MROs).*[27] *Despite the amount of pledged bonds surged, this does not necessarily imply that the liquidity withdrawn from the Eurosystem liquidity facilities also went up. The reason is that pledged bonds could just remain idle in the collateral pool of the Eurosystem without being used for liquidity withdrawals (even though these bonds could be used to collateralise intraday credit); in this case, the increase in the volume pledged would not reflect a funding stress. However, as Figure C.2 panel (b) shows, the counterparties which pledged the highest*

[26] Each group represents a quartile of the distribution, and the amounts pledged have been de-meaned by their averages prior to the jump.
[27] De-meaned by their respective pre-event averages.

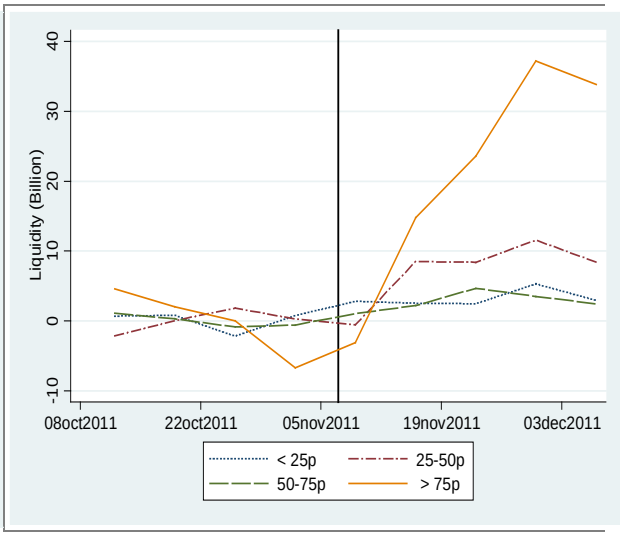
amount of Italian bonds (i.e. those counterparties in the top quartile) were also those which withdrew the highest amount of liquidity after 9 November 2011. The outstanding liquidity rose by 34 EUR billions. Equally important, Figures C.2 only consider the time window ranging from 7 October 2011 until 6 December 2011, i.e. before the ECB announced the launch of the 3-year LTROs. Therefore the LTRO liquidity facility considered in this figure refers to the previous operations, which was in place even before the financial crisis erupted in summer 2007.

Figure C.2: Italian sovereign debt pledged and liquidity drawn by groups of counterparties

(a) Collateral pledged



(b) Liquidity drawn



Note: The figure (a) presents the evolution of the total nominal amount of Italian sovereign bonds pledged to the Eurosystem by four groups of European banks. Each group represents a quartile of the distribution and the amounts pledged have been de-meaned by their respective pre-event averages. The counterparties are matched with each group based on the nominal amount of Italian sovereign bonds pledged to the Eurosystem on 6 December 2011. The figure (b) presents the total liquidity (LTRO + MRO) withdrawn by the same four groups, de-meaned by their respective pre-event averages). The vertical line refers to the increase in the haircuts by LCH Clearnet and CC&G (9 November 2011).

4.2 Eurosystem outright purchases and collateral markets

Scarcity and structural effects can be induced when the central bank aims to influence prices of collateral assets through outright purchases. Several studies quantify the impact of the Eurosystem's outright purchases on bond yields (Eser and Schwaab (2016), Ghysels and al (2016)) under the Security Market Programme (SMP).

Outright purchases can also have side effects on the collateral use of assets due to the effective decrease in supply of collateral for a given stock of assets. Corradin and Maddaloni (2017) document that SMP purchases increased specialness - the scarcity premium of procuring a bond in the repo market - of specific Italian government bonds in the second half of 2011. The increase in the premium to be paid to procure a specific bond is related to the amount purchased in every transaction but also to the holdings already in the Eurosystem's portfolio. These effects are amplified when the SMP purchases involve bonds already in high demand in the repo market due to short selling activity. Finally, they also show that bonds characterized by high level of specialness are more likely to be underlying fail to deliver transactions, having important externalities on the functioning of the bond markets. Beyond the functioning of the repo market, broader concerns are that the scarcity of collateral in repos could affect the liquidity in bond markets causing extreme volatility episodes.

Central banks can offset scarcity premia (or specialness) by introducing a security lending facility or similar activities, making their collateral available for reuse. D'Amico, Fan and Kistul (2017) find an economically substantial scarcity premium due to specialness in U.S. Treasury securities that were targeted by the Fed during their QE programme. However, their results suggest that the Fed lending facility (i.e. reverse repos providing collateral to the market) as a supplementary policy tool was effective in alleviating shortage of high-quality collateral due to the change of the net supply of Treasury collateral. In the same vein, the Eurosystem Public Sector Purchase Programme (PSPP) makes available the PSPP bonds to the market through a securities lending facility to mitigate impairments in the price mechanism.

On the other hand, recent research suggests that the direct purchase of government bonds in the cash market by the Eurosystem under the SMP might have stimulated borrowing demand for the bonds of the targeted countries alleviating short-term funding stress. Aggarwal, Bai and Laeven (2016) propose a new channel for central bank outright purchases. They find that lending fees for bonds in targeted countries decreased by 1.15 basis points on average relative to bond in countries that were not targeted during the first phase of the SMP when Greek, Irish and Portuguese bonds were purchased. Moreover, the SMP helped restore market confidence not only by reducing lending fees but also by boosting loan volumes of government bonds issued by the targeted countries. Their results suggest that direct purchases stimulate demand for bonds in the lending market, restoring the proper functioning of short term funding markets that are critical for the transmission of monetary policy.

5. Concluding remarks

This paper examines the role of collateral in the financial system, with a special emphasis on the implications for financial stability and the conduct of monetary policy. We argue that using collateral is no panacea to ensure financial stability. Collateralized transactions can be subject to pro-cyclicality, complex demand and supply concerns, as well as subject to intricate interactions of the public sector and private markets. In this context, the Eurosystem plays a key role in collateral markets via its collateral framework and its asset purchases. Accordingly, the design of its operations reflects their impact on private market functioning. Ultimately, ensuring financial stability requires both sound ex-ante regulation of the financial sector as well as ex-post back-stops in cases of private market malfunctioning and aggregate liquidity shortages.

We also reviewed the literature on the economics of central clearing. CCPs can play an important role in making efficient use of collateral, provided they are well governed and their advantages in terms of economies of scale are used optimally.

The following main take-aways emerge from our analysis.

First, collateral and margin requirements in private financial markets may be too pro-cyclical, leading to excessive leverage and over-borrowing in good times, and excessive de-leveraging and asset sales when bad news hit. Market outcomes can be inefficient due to, for example, the failure of individual agents to recognise that their leverage decisions impact the ability of other agents to leverage or due to fire-sale externalities whereby private agents fail to internalise the impact of their margin and liquidation decisions on market prices. Market outcomes may also be inefficient due to moral hazard in the case of the "too-big-to-fail" problem.

Even large market participants – like CCPs - may fail to internalise the effects of their actions on market outcomes. For example, CCPs use rule-based triggers to change the haircuts on repos. They may be led to change haircuts to protect themselves against potential losses. However, CCPs typically do not internalise that their rule-based haircut setting may generate adverse price dynamics: by applying such rules when the value of an asset falls below a pre-set threshold, CCPs may induce early contractions in the demand for this asset in anticipation that its value will indeed fall below the threshold. This is an important issue in the euro area where CCP clearing is predominant in private repo markets.

These inefficiencies call for macro-prudential regulation to correct the externalities. To prevent the build-up of excessive leverage, leverage may need to be restricted in optimistic times and minimum capital buffers need to be imposed. Capital buffers may also need to be specific to asset leverage, with higher requirements for high-leverage assets than for low-leverage assets.

To reduce pro-cyclical effects of haircut policies in private markets in general, and of CCP haircut policies in particular, regulatory interventions in margin setting should include margin floors as well as margin caps (or position limits). Permanent margin floors can help with under-margining by market participants due to, for example, failure to internalise fire-sale externalities in bad times. Such margin floors would only bind in good times (as in bad times, margins tend to increase to reflect increased risks) and they would reduce the need for a large increase in margins when bad

news hit. By contrast, margin caps would only bind in bad times when margining may be excessive and self-defeating due to adverse fire-sales dynamics in asset markets (whereby margin calls trigger asset sales, which depress asset prices, triggering further margin calls and so on). While an increase in margins is warranted when risks increase, appropriately calibrated margin caps could help eliminate equilibria with excessive margining and too low asset prices.

Second, CCPs can bring about netting and collateral savings benefits, as well as risk reduction but clearing arrangements must be designed to preserve clearing members' incentives for prudent risk-management, as well as to mitigate potential moral hazard stemming from the too-big-to-fail problem. Supervisors must ensure that CCPs have sufficient liquidity buffers and loss-absorption capacity (through equity capital, default funds and margins). Moreover, to reap the benefit of central clearing, it is key that loss-sharing rules among CCP members and resolution plans in case of default are clearly specified and that CCP risk-management practices are robust to market stress. Also, CCP internal models for setting margin requirements should be transparent to avoid destabilising impact on markets. Interoperability between different CCPs would enable a CCP to observe positions that their counterparties hold with other CCPs which is critical for a CCP to set margins correctly.

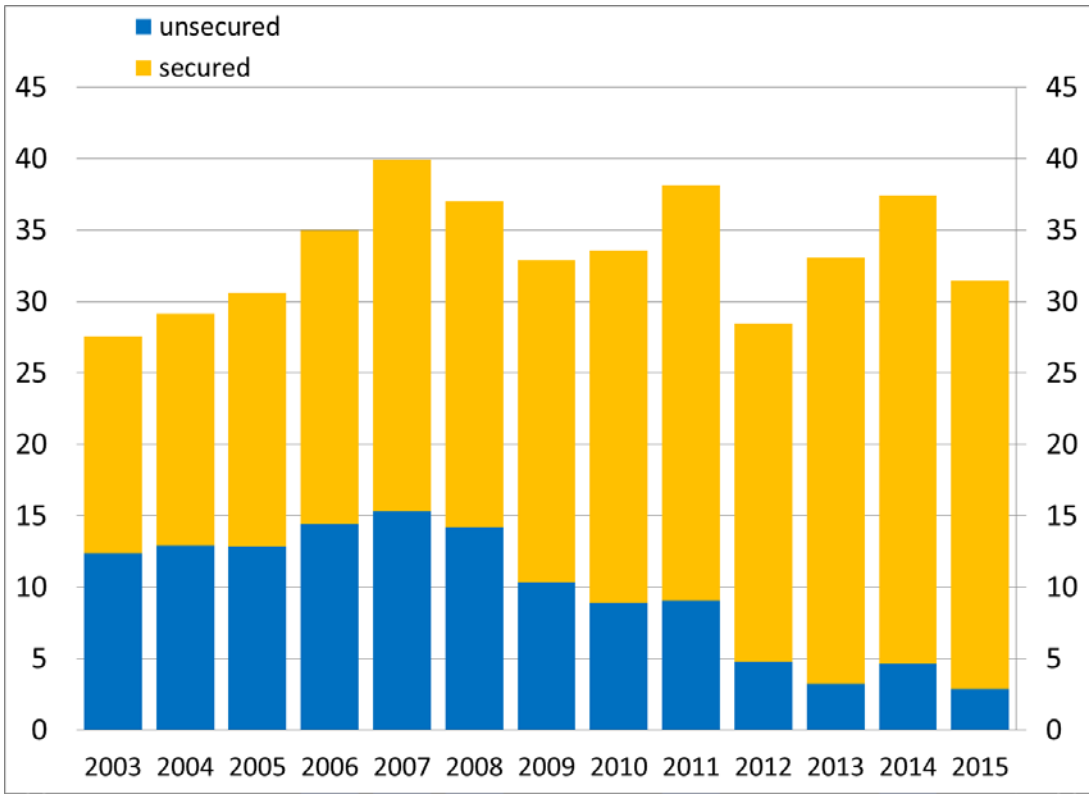
Third, central bank operations, due to their collateralised nature, interact with, and affect the functioning of, the secured markets in complex ways. Our discussion highlights how central bank operations can improve liquidity and market functioning. However, they can also "withdraw" collateral assets, which may contribute to a scarcity of good collateral and to the "specialness" of some assets or asset classes. The latter may become a growing concern as the Eurosystem continues to increase its public sector securities holdings.

Particularly when high-quality collateral is scarce, well-functioning unsecured markets can alleviate funding stress. Unsecured markets do not require costly collateral. Moreover, unsecured money markets can have an added benefit if they encourage monitoring of borrowers by their money market lenders. The functioning of unsecured markets depends critically on the level and distribution of risk in the banking sector, as unsecured creditors' claim is not backed by any collateral. A healthy banking sector is therefore a pre-condition for a smooth functioning of unsecured markets.

Moreover, the functioning of secured and unsecured markets are not independent of each other, and fragility in one market segment can spill-over to the other market segment. For example, if a larger share of a borrower's balance sheet is pledged as collateral in secured transactions, this reduces the asset share that supports unsecured creditors, making unsecured funding more expensive. Also, if some borrowers lose access to the unsecured markets, they may need to acquire collateral to access secured funding, which increases demand for assets that can be used as collateral and can lower return on these assets, affecting all other holders of these assets.

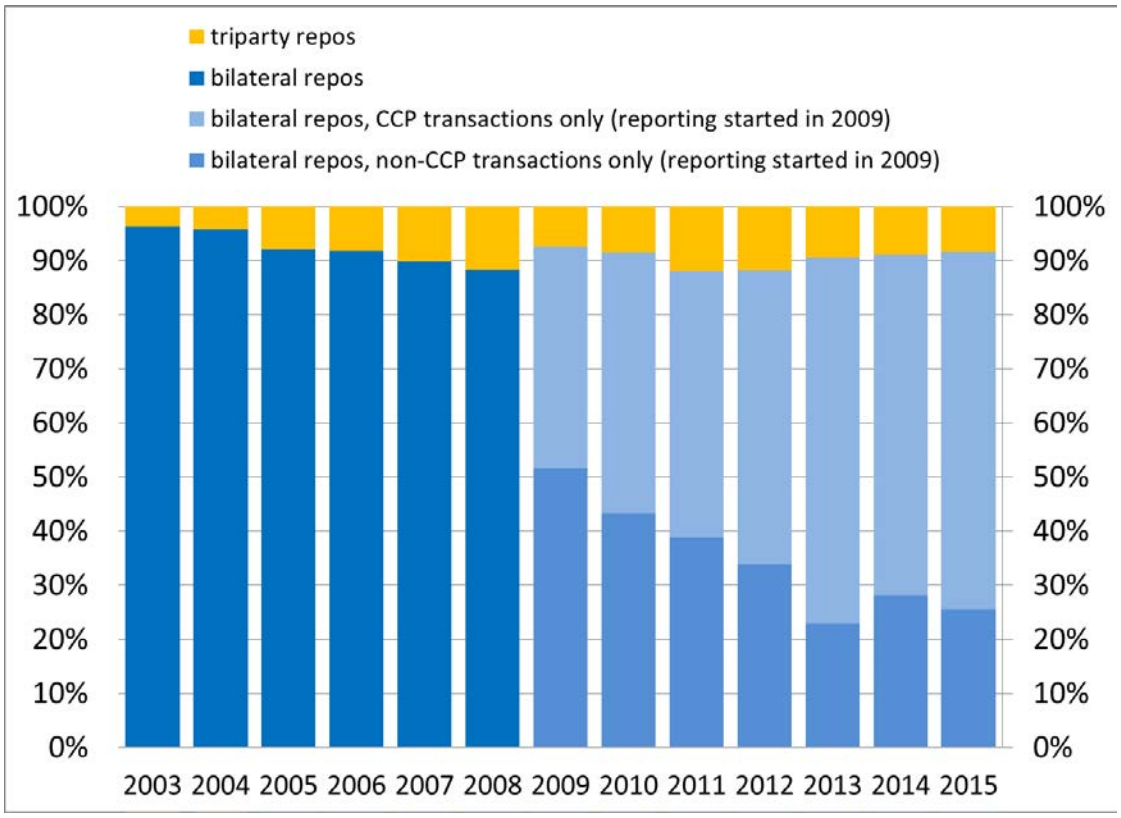
In sum, ensuring a smooth functioning of secured (and unsecured) markets is an important, yet challenging task. It requires, inter alia, micro-prudential supervision to address weaknesses in individual bank balance sheets, macro-prudential regulation to address market failures in collateralised markets, as well as a sufficient supply of safe public assets that can be used as collateral in secured markets.

Figure 1: Evolution of secured and unsecured money markets in the euro area



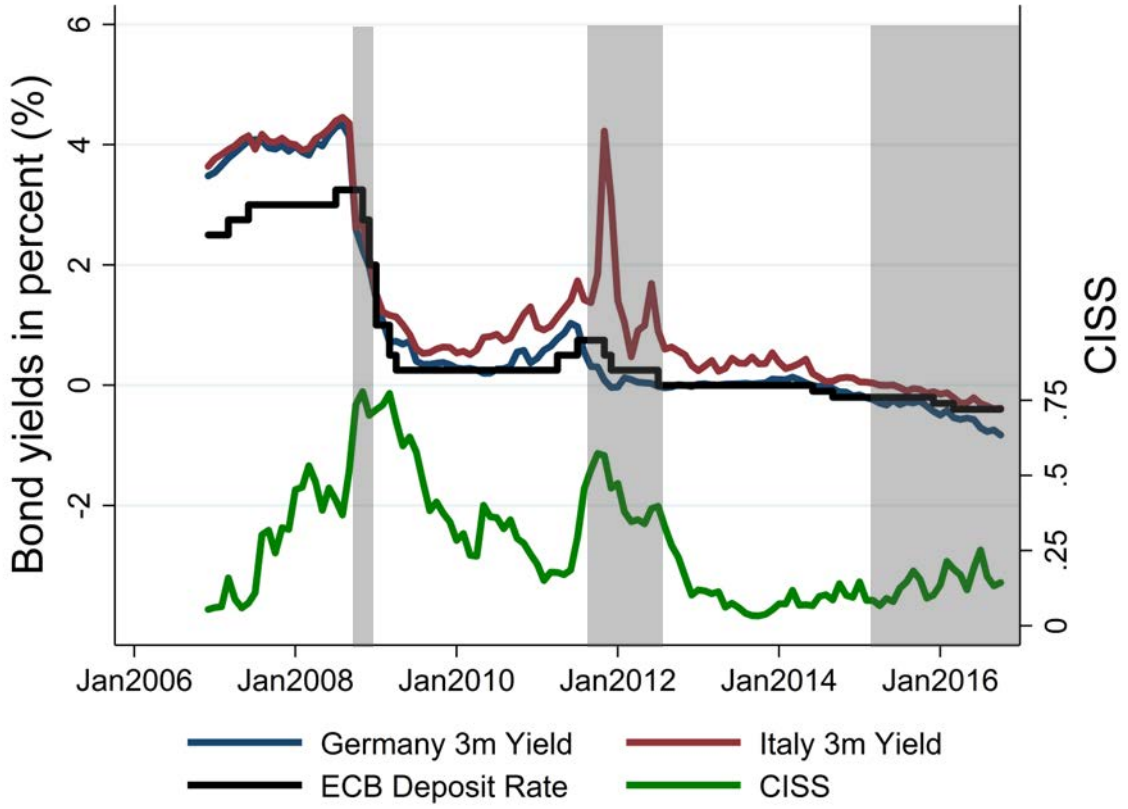
Note: cumulative quarterly turnover in the euro money market (EUR trillion)
Source: ECB Money Market Surver (ECB, 2015)

Figure 2: Importance of clearing in the euro area repo markets



Note: Breakdown of total secured debt (percentages of total)
Source: ECB Money Market Survey (ECB, 2015)

Figure 3: Government bond yields, ECB deposit rate and financial stress



Note: On the left-hand side German and Italy 3 months bond yields and ECB deposit rate. On the right-hand side CISS-Composite Indicator of Systemic Stress based on Holló, Kremer and Lo Duca (2012).
Source: ECB, SDW and Bloomberg

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