Central Bank Collateral Policy and Financial Fragility [1]

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Abstract

Central bank collateral policy and financial fragility

This paper discusses the role of central bank collateral policy with respect to financial stability. This is an important tool of the central bank and an integral aspect of monetary policy. Collateral frameworks determine what collateral central bank money is issued against and on what terms. Evidence is provided that the collateral framework in the euro area impinges on market discipline. Haircuts in Eurosystem repos do not respond to market forces, most eligible collateral do not have market prices, implying a need for theoretical prices, and collateral policy favors illiquid and bank-originated collateral. This promotes a bank-oriented financial system, which, in turn, leads to greater financial fragility and less innovation. Both effects reduce welfare. The theoretical analysis suggests that the construction and promotion (through collateral policy) of liquid assets could be a catalyst for a more stable financial system.

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Monetary policy does affect pricing in today's market to such an extent that monetary policy itself has been a risk you have to watch.
–Yngve Slyngstad, Head of the Norwegian sovereign wealth fund, April 2015.

1. Introduction

Central banks are typically viewed as pillars of stability, designing and implementing policies to promote stability in the economy and the financial system. The campaign to establish the Federal Reserve System in the early 1900s in the United States, for example, was won through arguments that it would help stabilize the financial system and the economy (Lowenstein, 2015). More recently, central banks around the world have been the main players in the attempt to slow down what at one stage appeared to be a runaway financial crisis. Even so, many commentators have criticized central banks for creating risks. The European Central Bank (ECB) has recently even been accused of being significantly culpable with respect to the growth in right wing populist political movements in Europe.[1] It is, therefore, important to have a clearer understanding as to what central banks actually do, and how their policies may potentially adversely affect the financial system, the real economy, and society. This paper contributes to that agenda by considering the potential impact of central banks' collateral policies and, in particular, on how collateral policy may affect financial stability and economic welfare.

The current paper relates to recent works by Nyborg (2015, 2016) that put forth the view that central banks' collateral policies, as described and defined in their collateral frameworks, represent an important monetary policy tool that can be – and is – used to influence capital markets, the financial system, and the economy. This view has its basis in the fact that central bank money is issued against collateral on terms defined by the central bank through its collateral framework. This places collateral policy at the core of the monetary and financial system. To understand what this means in practice, Nyborg (2016) undertakes an in-depth, forensic-style analysis of the Eurosystem's collateral framework, reaching the conclusion that it is used to influence markets, rather than being a reflection of market conditions. The implication is that the collateral framework is a monetary policy

[1] See, for example, "ECB on defensive against German onslaught," by C. Jones and S. Wagstyl, *Financial Times*, 21 April 2016, p. 4.

tool.

This paper develops the ideas in Nyborg (2015, 2016) in the direction of the potential influence of collateral policy on financial stability. First, I present some new and updated evidence that speaks to the hypothesis that the Eurosystem's collateral framework circumvents market forces. Second, I expand on the idea, articulated by Nyborg (2015, 2016), that the collateral that is produced in the economy responds endogenously to the incentives created by the central bank's collateral framework. I make use of a simple theoretical setup in the Diamond and Dybvig (1983) tradition, where fragility arises as a result of liquidity provisioning through (endogenous) maturity transformation (banking). This is juxtaposed with liquidity provisioning through intermediated markets (Jacklin, 1987). The markets solution has the advantage of being less fragile. However, I argue that it requires the availability of liquid assets to be credible. Thus, a policy that favors illiquid collateral tilts the economy towards investing capital in relatively illiquid real assets while, simultaneously, expanding the banking sector and increasing financial fragility. The model provides a specific example as to how a central bank's collateral policy may influence welfare and financial stability. In particular, it provides an illustration of the idea that there may be a positive relation between financial fragility and the size of the banking sector, as a function of collateral policy. The analysis also delivers the result that a bank-dominated financial system stifles technological innovation, which also reduces welfare.

The topic of financial stability is often put under the rubric of macroprudential policy, regulation, and supervision. In contrast, monetary policy is typically thought of as dealing primarily with price stability. Macroprudential and monetary policy are typically separated (see, e.g., Galati and Moessner, 2013). There is growing recognition, however, that this is a false dichotomy (see, e.g., Freixas, Martin, and Skeie, 2011; Borio, 2014). A current theme in the financial press is that today's ultra-low interest rates are a challenge to banks and life insurers, that struggle to earn sufficient returns to earn the cost of capital and meet their fixed liabilities. As a result, both types of financial institutions may be tempted to take on more risk, with potentially distressing consequences for financial stability. The arguments in this paper support the view that monetary policy affects financial stability, but my focus is on collateral policy rather than on interest rates.

The fundamental importance of central banks' collateral frameworks derives from the significance of their money, often referred to as outside money (Gurley and Shaw, 1960).

While influential contributions by Kiyotaki and Moore (2003) and Holmström and Tirole (2011) emphasize the importance of inside money, Kiyotaki and Moore also recognize that their conclusion of the primacy of inside money may be controversial because, in practice, "assets such as bonds [that serve as inside money] are promises to pay in outside money." In other words, the money generated by banks and other players within the financial system are anchored to central bank money. Furthermore, it is the central bank that decides on the terms of exchange between inside money (collateral) and outside money, and it does so through its collateral policy. This underscores the importance of collateral policy.

In modern economies, central bank money underpins economic activity. Financial and economic transactions ultimately give rise to a transfer in central bank money, either electronically through the payment system or physically through banknotes. Banks are at the center of these transactions. For this reason and because of minimum reserve requirements, having sufficient central bank money is a hard constraint for banks. This matters to such an extent that, empirically, tight conditions in the interbank market affect volume, prices, and order imbalance in financial markets as banks trade, or induce trade, to generate the liquidity they need (Nyborg and Östberg, 2014). Again, because central bank money is ultimately issued against collateral, this points to the importance of a central bank's collateral framework.

The prominence of central bank money may be a result of moral hazard within the financial system (Kiyotaki and Moore, 2003; Holmström and Tirole, 2011). But it may also be the result of a political process. As argued by Nyborg (2015, 2016) this bestows substantial power on to the central bank. If the central bank's collateral policy favors particular assets, then we would expect more of these to be produced. For example, if the central bank provides liquidity against relatively generous terms to illiquid assets in order to "channel liquidity where it is needed," then we would expect illiquid assets to be produced and brought to the central bank. In turn, this may also affect investments in the real economy; a central bank that favors illiquid collateral may end up promoting investments in illiquid real assets, such as housing. As aphoristically put by Nyborg (2016): "if central bank money is available only against igloos, or igloo-backed securities, igloos will be built." While this is an extreme and fanciful example, there is emerging, direct evidence that supports Nyborg's thesis that the collateral framework directly influences banks' lending behavior and thus real investments (van Bekkum, Gabarro, and Irani, 2016). With respect to the current paper, the point is that if the monopoly provider of money favors illiquid assets through its collateral framework, the financial system will become more fragile over time. It is, therefore, important to assess central banks' collateral frameworks from a macroprudential perspective.

This paper contributes by assessing the Eurosystem's collateral framework. I provide updated evidence that the Eurosystem's collateral framework circumvents market forces and is biased in favor of illiquid and bank-issued collateral. I also provide evidence that illustrates that the ECB's unconventional monetary policies have gotten increasingly strong over time. This may be the central bank's response to a system that has become increasingly fragile over time, perhaps as a result of the policies that the central bank itself pursues.

The rest of the paper is organized as follows. To put the Eurosystem's collateral framework in context, Section 2 provides a brief background on monetary policy in the euro area. Section 3 then takes a closer look at the collateral framework itself, presenting evidence that it sidesteps market forces and favors illiquid and bank issued collateral. Section 4 contains a theoretical discussion. Section 5 provides further discussion and concluding remarks.

2. Overview of monetary policy in the euro area

Through their monetary policy operations, central banks provide liquidity against collateral. Thus, collateral policy is an integral part of monetary policy. To put the collateral framework of the Eurosystem in context, this section provides a brief overview of the main non-collateral instruments of monetary policy in the euro area from the introduction of the euro in 1999 to the spring of 2016.[2] I first review the conventional regime, which ran for approximately nine years, until the turmoil that arose in the wake of Lehman's default in September 2008 ushered in an era of unconventional monetary policies. These began in October 2008 and have been considerably ramped up since then.

[2]For further details, see Bindseil (2014) and Nyborg (2016). Bindseil and Nyborg (2008) contains a comparison of monetary policy implementation across various countries and currency areas.

2.1 The conventional era: January 1999, to October 2008

Until October 2008, the ECB operated with what Nyborg, Bindseil, and Strebulaev (2002) refer to as a liquidity-neutral policy. This can be described as the central bank injecting the quantity of liquidity banks need, in aggregate, to fulfill reserve requirements and satisfy other liquidity needs. For example, if money flows out of the banking system for reasons such as increased demand for banknotes, government deposits with the central bank, or foreign exchange trades, the central bank compensates by injecting additional central bank money. The key element of the liquidity-neutral policy is that there is just sufficient liquidity for banks, in aggregate, to satisfy reserve requirements. This then allows the central bank to control the overnight rate close to its policy rate, when the liquidity-neutral policy is combined with lending and deposit facilities in a symmetric corridor around the policy rate.[3] The ECB operated with a 200 basis point (bp) corridor until October 2008, when it was reduced to 100 bp and has subsequently been subject to further change.

The need for banks to satisfy reserve requirements is thus a key factor in how the central bank controls interest rates. In the euro area, reserve requirements are a fixed percentage of short-term liabilities.[4] This was two percent until January 18, 2012, when it was lowered to one percent. Additional central bank money is thus injected as aggregate deposits grow. Since a bank loan is made in the form of a deposit on the account of the borrower, this also means that the monetary base will tend to grow in tandem with bank lending to households or businesses. In turn, this means that the (minimum) value of the collateral that banks post with the central bank must increase. Section 3 discusses the kind of collateral that banks in the euro area use for this purpose.

In the euro area, the two most significant conventional operations are the main refinancing operations (MROs) and the longer-term refinancing operations (LTROs). These operations are conducted on a collateralized loan (or repo) basis, whereby banks put collateral "on account" with the central bank to cover their liquidity uptakes in the operations. Since March 2004, the MROs have had a one-week maturity. The LTROs had maturities of approximately three months until October 2008, since when some LTROs with longer

[3]See, e.g., Bindseil, Nyborg, and Strebulaev (2009) for a more detailed discussion as to how this works and Nautz and Offermanns (2007) for evidence on the (quite small) deviations between the overnight and policy rates. This can also be seen in Figure 1.

[4]See, e.g., Fecht, Nyborg, and Rocholl (2011) for details.

maturities have been held. The MROs and LTROs were conducted as discriminatory auctions from June 2000 and March 1999, respectively, until October 2008. The MROs lived up to their name as *main* refinancing operations until September 2007, one month after the onset of the financial crisis. Over the January 1999, to August 2007 period, the ratio of the daily outstanding volumes of central bank money injected via the MROs and LTROs was approximately, and fairly consistently, three-to-one (Nyborg, 2016). Since September 2007, the daily outstanding volume from LTROs has been larger. For example, from December 2011 to December 2014, the ratio of LTRO to MRO daily outstanding volumes averages to approximately seven-to-one (Nyborg, 2016). The MROs could perhaps now more aptly be referred to as the *marginal* refinancing operations.

Insert Table 1 here.

To get a sense of the combined importance of the MROs and LTROs, Table 1, shows the asset side of the consolidated Eurosystem balance sheet from 1999 to 2015. The key item for our purposes here is item 5, which consists primarily of MROs and LTROs.[5] As a fraction of the total balance sheet, item 5 have stayed in a band between 20.1% (2015) and 41.9% (2007). Until 2015, roughly a third of the Eurosystem's balance sheet is represented by collateralized loans, or repos. Up until the introduction of quantitative easing in the fall of 2014, this also represented the vast majority of the Eurosystem's injections of central bank money. The collateral that back up the MROs and LTROs are chosen by banks themselves, within the constraints provided by the Eurosystem's collateral framework.

2.2 The unconventional era: From October 2008

The two most significant unconventional monetary policies introduced by the ECB are the full-allotment policy and quantitative easing (non-sterilized asset purchases). Full allotment under fixed-rate tenders replaced the old liquidity-neutral policy in October 2008. Under full allotment, banks receive as much central bank money as they ask for in the MROs and LTROs, at a fixed rate. Their only constraint is that they have to post sufficient collateral. This policy accounts for the rise in item 5 of the Eurosystem's consolidated balance sheet in 2008. Since the introduction of full allotment, the maximum maturity of the LTROs have gradually lengthened to six months (October 2008), one year (June 2009), three years

[5]See Nyborg (2016) for details.

(December 2011), and four years (September 2014).

Quantitative easing was announced in September 2014, initially focusing on purchases of covered bonds and, to a lesser extent, asset-backed securities. It was then expanded in January 2015 to also include government and other public-sector bonds. The ECB had run three asset-purchase programs before this, but these did not represent pure quantitative easing as they were, at least nominally, sterilized.[6] Quantitative easing started on a relatively small scale in October 2014 and was then ramped up to around EUR 60 billion per month in March 2015, when the Eurosystem started buying public-sector bonds. This coincided with the falling due of the second of the two three-year LTROs, which also illustrates the spiral of ever-stronger monetary medicine administered by the ECB. In March 2016, it was announced that the purchasing level would expand to approximately EUR 80 billion per month as of April 2016 and also include corporate bonds.[7] These purchases represent a massive injection of central bank money against collateral and explain the huge increase in item 7 (securities of euro-area residents denominated in euros) in the Eurosystem's consolidated balance sheet in 2015. This is also the first year item 7 surpassed item 5.

The discussion here illustrates that the unconventional monetary policies of the ECB have become increasingly stronger over time. This is reflected in the growth in the size of the consolidated Eurosystem balance sheet as a percentage of euro-area GDP. As seen in Table 1, this has increased from 11% in 2004 to 24% in 2013.

What started as relatively short-term full-allotment operations have ended up with four-year full-allotment operations and the purchasing of eighty billion euros worth of public sector paper, covered bonds, and to a much smaller extent, ABSs per month. It is striking that the unconventional monetary policy era of the ECB has now lasted just about as long as the conventional monetary policy era. The length of the unconventional monetary policy era and the continued ramping of the strength of the policies represent an underlying weakness in the financial system in Europe. The underlying fragility may grow as a result of the increasingly accommodative and forgiving monetary policy that is being pursued by the ECB. In turn, this may be the result of the fundamental imbalances in the euro area between countries. The accommodativeness of Eurosystem collateral policy can be seen by

[6]See Nyborg (2016) for a discussion on the "sterilization" of the Securities Market Programme (SMP). See also Eser and Schwaab (2016) for an in-depth analysis of this program.

[7]The first corporate bonds were bought in June, 2016.

comparing item 5 in the consolidated balance sheet (Table 5) with the nominal value of eligible marketable collateral. For example, in 2013, while banks only needed around EUR 700 billion of collateral, the value of eligible collateral was in the neighborhood of EUR 14 trillion (Table 1). As discussed by Nyborg (2016) much of the eligible collateral has virtually zero opportunity cost; it has no use in the markets.

2.3 Monetary imbalances and dysfunction

The full-allotment policy has been accompanied by the phenomenon that banks hold excess liquidity in aggregate, as illustrated in Figure 1. As a result, there has been a heavy usage of the deposit facility, and the overnight rate has started to track the deposit rate rather than the "policy" rate, as also seen in Figure 1. In effect, under full allotment, the ECB has been running a floor, rather than a corridor, system to control the overnight rate.[8]

Insert Figure 1 here.

That banks take up more central bank money than what they need in aggregate is a sign of dysfunction. It is also costly. Banks pay the policy rate for the liquidity they obtain in the MROs and LTROs, but earn a lower rate at the deposit facility (which has even turned negative). That banks prefer to use the deposit facility rather than lend to other banks that are short liquidity reflects underlying fragility and weakness. The problems with the sovereigns in the euro-area periphery (Portugal, Italy, Ireland, Greece, Spain, and Cyprus) are well documented, as evidenced by their ratings, yield spreads, and deficits. Based on statistics from the BIS, Cline (2014) also provides evidence of a massive outflow of capital from these countries, and Nyborg (2016) documents heavy usage of Italian government guarantees to collateral issued by Italian credit institutions. The continued use of the full-

[8] While it is difficult to provide an exact date for the beginning of the financial crisis, Figure 1 uses the date August 7, 2007. The reason is as follows: On August 6, 2007, American Home Mortgage Investment Corp. filed for Chapter 11 Bankruptcy (`www.sec.gov/Archives/edgar/data/1256536/000091412107001892/am9746838-99_1.txt`). Then, on August 9, BNP Paribas issued a press release announcing a temporary suspension of the calculation of net asset values as well as subscriptions/redemptions for three investment funds, backdated to August 7, 2007, saying: "The valuation of these funds and the issue/redemption process will resume as soon as liquidity returns to the market allowing NAV to be calculated." (`www.bnpparibas.com/en/news/press-release/bnp-paribas-investment-partners-temporaly-suspends-calculation-net-asset-value-fo`).

allotment policy and the massive size of the ECB's quantitative easing program is most plausibly a response to these problems (see Nyborg, 2016, for an in-depth discussion). It is difficult to interpret the purchasing of bonds and LTRO "liquidity" of one, three, and four years as anything but indirect bailout funding. The imbalances in the euro area is arguably the most significant macroprudential issue of our times, and collateral is a critical part of this because liquidity, or funding, is provided against collateral. The growing size of the central bank also illustrates the rising significance of collateral. It is, therefore, important to understand central bank collateral policy better.

3. Collateral framework

This section focuses on the collateral framework as it relates to the central bank money injected through repos, that is, through the MROs, LTROs, and the marginal lending facility. As discussed above, this was the main source of liquidity directly from the central bank in the euro area until quantitative easing was introduced in the fall of 2014. The refinancing operations and the standing facilities still constitute the main instruments through which the ECB controls the overnight rate and, unlike asset purchases, are directly targeted to banks. This underscores the importance of the collateral framework as it pertains to these operations and repos in general. The collateral framework is also relevant with respect to asset purchases, but my main focus here is on repos.

3.1 Collateral values

The collateral framework defines the criteria that must be met by collateral to be eligible, for example with respect to credit standards. It also sets the terms of exchange between central bank money and collateral. It determines how much central bank money the central bank is willing to provide against a specific eligible collateral. This important quantity is a collateral's value within the collateral framework.

For eligible collateral i at time t, its *collateral value*, $V^c_{i,t}$, is given by

$$V^c_{i,t} = (1 - h_{i,t})V^m_{i,t}, \tag{1}$$

where $h_{i,t}$ is the haircut applied by the central bank, and $V^m_{i,t}$ is the price of the collateral. While it is tempting to think of V^m as a market price, the Eurosystem's collateral framework also allows for the price to be determined theoretically if a sufficiently "fresh" market price does not exist.[9] So V^m can be thought of equally as a model or a market price.

Equation (1) shows that haircuts and official Eurosystem prices (V^m) play a key role in the money creation process. These factors affect the relative attractiveness to banks of different collateral within the collateral framework. Banks would be expected to prefer using collateral that has a relatively high value within the collateral framework as compared with in the market. This gives rise to three basic questions:

- What is the set of eligible collateral?
- How are haircuts set?
- What is the incidence of the usage of theoretical prices and how does this vary across different types of collateral?

I will address these questions in turn.

3.2 Eligible collateral

The set of eligible collateral is large by any reasonable measure. It includes a wide range of fixed-income securities such as government bonds, covered bonds, corporate bonds, unsecured bank bonds, and asset-backed securities (ABSs). Non-marketable collateral such as credit claims may also be eligible. Equities were eligible until 2005.

Marketable eligible collateral can be organized into two sets. The "visible" set is the public list of eligible collateral, which is updated daily and published on the ECB's website. This contains all marketable collateral that is eligible by virtue of having a public rating, or being guaranteed by an entity with a public rating, that meets with the minimum threshold as determined by the ECB. Since October 2008, the minimum requirement is a rating of BBB− on Standard & Poor's (S&P) scale.[10] There are four accepted rating agencies; namely, S&P, Fitch, Moody's, and Dominion Bond Rating Services (DBRS). But only the

[9] See Nyborg (2016) and the references therein for details. Model prices are also used by other central banks, for example, the Federal Reserve System, in their collateral frameworks.

[10] Since May 1, 2015, the minimum ratings criterion can also be met by a sufficiently high short-term rating. See, Nyborg (2016) and the references therein for details.

highest rating matters. The public list of eligible marketable collateral typically numbers 30,000 to 40,000 ISINs, but sometimes more.

The second, less visible, set of eligible marketable collateral consists of what Nyborg (2016) refers to as "privately eligible collateral." This consists of securities, without public ratings, issued or guaranteed by non-financial corporations from the euro area. Such securities may be deemed eligible if they have a sufficiently high rating from an approved in-house, NCB, or third-party rating model. The official collateral framework documentation specifies very clearly that these securities are not on the public list (see Nyborg, 2016, for details). It is difficult to say how many such securities there are and what their combined value might be. My focus here is, therefore, on the public list.

Insert Figure 2 here.

Figure 2 plots the number of collateral on the public list from April 2010 to May 2016.[11] Subfigures 2a and 2b categorize eligible collateral by country of residence of the issuer and type of collateral, respectively.

The collateral types in (2b) represent what the ECB refers to as *liquidity categories*.[12] These categories are as follows: I. Central government and central bank debt; II. Local and regional government debt, jumbo covered bonds (pfandbrief), agency and supranational (or international organization) debt instruments; III. Covered bonds and corporate bonds; IV. Unsecured credit institution debt instruments;[13] IV. Asset-backed securities. As will be seen below, Eurosystem haircuts are increasing in the liquidity category, which reflects the perception that securities are increasingly less liquid as we move up the liquidity category scale. For now, I wish to draw attention to three observations regarding the public list of eligible collateral.

First, the number of ISINs typically varies between 30,000 to 40,000, but was close to 45,000 in 2010. Second, the most common type of eligible collateral (by count) is by far unsecured bank bonds (category IV). Third, there is a drastic reduction in the

[11]The start date is determined by the public availability of historic data. The figure here is based on Figure 9.1 in Nyborg (2016), but extends the end-date of the coverage period from September 15, 2014 to May 3, 2016.

[12]More recently, the ECB operates with the terminology *haircut categories* instead of *liquidity categories*.

[13]As of October 2008, this also includes unsecured debt instruments issued by other financial corporations.

number of eligible collateral at the year-change 2010/2011, which reverses at the year-change 2011/2012. As seen in Figure 2b, this affects almost exclusively unsecured bank bonds. As explained by Nyborg (2016), this relates to the exclusion and subsequent re-introduction of more than 10,000 ISINs trading on non-regulated markets.

The re-admission of this highly illiquid set of collateral at the year-change 2011/2012 was in time to take advantage of the second of the two three-year LTROs, which injected about half a trillion euros of three-year money into the banking sector, against collateral. The timing is highly suggestive of the provisioning not only of "liquidity" but of support for weaker banks and markets. The countries that saw the largest increase in the number of eligible collateral, from the re-introduction of the unsecured bank bonds trading on non-regulated markets (France and Italy, see Figure 2a), were also among the three most heavy users of the three-year LTROs, the third country being Spain (see, e.g., Nyborg, 2016).

The third observation is illustrative of a broader theme regarding the Eurosystem's collateral framework, namely the substantial tinkering with it at times that often coincide with important (un)conventional monetary policy initiatives. More generally, Figure 2 gives an indication of the extremely accommodating eligibility rules that exist in the euro area. It is hard to find a fixed-income security that is not eligible.

3.3 Haircuts

Equation (1) shows that the terms at which eligible collateral can be exchanged for central bank money directly with the central bank is to a large extent determined by haircuts. These haircuts are set by the central bank and constitute an important element of its collateral policy. The ECB's policy is to update haircuts only infrequently. Nyborg (2016) documents that since 2004 to the present, haircuts have been updated only four times. Thus, the most important point to note about the Eurosystem's haircuts is that they do not reflect market conditions.

Haircuts for marketable collateral are set tables published in the official collateral framework documentation. Table 2 is the most recent such haircut table. This came into force on May 2015 and is still valid one year later. As seen, haircuts increase in risk, as captured by duration and credit rating. They also increase in illiquidity, as captured by the liquidity category. However, within each cell in the haircut table, there is no consideration of a specific piece of collateral's idiosyncratic characteristics or market liquidity. The haircuts are also independent of the counterparty. This reinforces the general point that market conditions play virtually no role in the determination of haircuts.

Insert Table 2 here.

3.4 Prices

As observed above, the prices that are used to determine collateral values within the collateral framework may be model-based as well as being market prices. In this section, I examine the incidence of theoretical prices among ISINs on the public list of eligible collateral. This is done by feeding all ISINs on the public list into the Bloomberg system at the end of each trading day and checking the reported price source. The sample period runs from December 11, 2014 to April 21, 2016. This relatively short time period reflects that the price-source data is not available historically; it has to be downloaded on a day-by-day basis and I started daily downloading of this data on December 11, 2014.

On any given day, the Bloomberg price-source variable classifies individual ISINs into five categories.[14] In addition, some ISINs are either not found in Bloomberg or found but without a price. Thus, ISINs are classified into seven categories as follows: (1) BVAL – a model price (but the model is not public information); (2) ISIN not found in Bloomberg; (3) the ISIN is found but there is no price; (4) BGN – a "consensus" price provided by Bloomberg; (5) LCPR – "a price source used for emerging market bonds. It is the latest price [quote] or yield from a basket of contributors." (6) TRAC – OTC market transaction prices from TRACE;[15] (7) EXCH – indicative prices from exchanges. Only TRAC unambiguously represents traded prices.

While it is possible that the Eurosystem collects price information from a wider range of sources than Bloomberg, this is arguably the most widely used platform in the financial industry. Bloomberg also collects and reports information from a wide range of sources. ISINs that cannot be found in Bloomberg or are in Bloomberg without a price are likely to be very thinly-traded securities with questionable market prices, if any. I therefore assign these two categories [(2) and (3)] along with category (1, BVAL) to the rubric "theoretical prices." The price-source flags BGN, EXCH, TRAC, and LCPR are classified as indicating

[14] BVAL, BGN, LCPR, EXCH, and TRAC.

[15] See `http://www.finra.org/industry/trace`.

"market prices." However, with the exception of TRAC, these sources do not necessarily represent actual, traded prices. It is also unclear what kind of depth the prices are good for. One may, therefore, question the extent to which these flags indicate "true" market prices. However, I count securities with these classifications as belonging to the "market price" category for the purpose of the statistics I report below. This means that my "market price" figures may overestimate the true set of ISINs that have their collateral values determined by meaningful market prices. Conversely, my reported figures of the incidence of "theoretical prices" may be underestimates. Another reason for this "conservative" bias in my figures is that my estimates here do not take account of stale prices. If prices do not move for several days, the Eurosystem uses a model price when determining a security's collateral value.[16]

I have examined the stability of the pricing source over time. In particular, for each ISIN, I compare the pricing source one day to the next. Across sample days, the fraction of ISINs that keep their pricing source averages to 99.6%, with a standard deviation of 0.5%. The minimum is 95.1% (on January 4, 2016). Thus, for individual securities, the pricing source is extremely stable over time.

Insert Table 3 and Figure 3 here.

The table reports that the mean fraction of theoretical prices among the ISINs on the public list of eligible collateral is 72%. As seen, the incidence of theoretical prices is generally higher in the higher liquidity categories. However, liquidity category IV (unsecured bank bonds) sees a higher fraction of theoretical prices (approximately 80%) than category V (ABSs, approximately 70%). Figure 3 shows that within liquidity categories, the incidence of theoretical prices is quite stable over time. This reflects the high stability of the pricing source among individual ISINs.

The conclusion in this subsection is thus that theoretical prices is the rule, rather than the exception, with respect to determining collateral values for individual ISINs. This supports the conclusion from the previous subsection on haircuts that market forces are largely absent in the Eurosystem's collateral framework. The implication is that the collateral framework is a policy tool that can be used to favor particular kinds of collateral, for example, securities trading on non-regulated markets or other highly illiquid collateral.

[16]See Nyborg (2016) and the references therein for details.

To see what kind of collateral the Eurosystem favors, it is necessary to look at usage statistics.

3.5 Usage of collateral

The lack of market forces with respect to setting haircuts and the very low reliance on market prices in the setting of collateral values within the Eurosystem's collateral framework means that there can be a divergence between the relative values of collateral within the Eurosystem's collateral framework as compared with in the markets. One would expect banks to use the type of collateral that is valued relatively highly within the collateral framework, as compared with in the markets, and that has the lowest opportunity cost. What this might be can be deduced by banks' preferences as revealed by their actual usage.

Insert Figure 4 here.

The evidence is in Figure 4.[17] This contains two charts. Figure 4a shows the nominal value of eligible marketable collateral, broken down by types that roughly correspond to the liquidity categories discussed above. This particular decomposition is dictated by how the data is provided by the ECB (on its webpage). The different collateral types are color-coordinated. Shades of blue represent relatively high-quality collateral (government, agency, and supranational debt securities).[18] Shades of red represent intermediate-quality collateral (covered bonds and corporate bonds). Shades of green represent low-quality collateral (unsecured bank bonds and asset-backed securities). The figure shows that the blue bars typically stretch into the 50% range and, when combined with the red bars, well into the 70% range and higher. However, at the height of the financial crisis there was a relative explosion of unsecured bank bonds that took this category, in combination with ABSs, to more than 30% of the eligible collateral by value. Combined with the "count data" seen previously, Figure 4a also implies that while there is a very large number of unsecured bank bonds on the public list of eligible collateral, these are relatively small by value.

Figure 4b presents the same kind of bar chart, but now for collateral used. This also

[17] Figure 4 is based on Figure 4.1 in Nyborg (2016), but adds the years 2014 and 2015.

[18] Obviously, since the onset of the crisis it is clear that not all government bonds are necessarily "high quality."

includes non-marketable collateral, indicated by white bars with green dots, sitting on top of the ABS bars. The figure shows a clear preference for the usage of low-quality collateral. While the highest-quality collateral (blue bars) typically hovers around 50% by value, it only represents around 15–30% by usage. Non-marketable collateral is also seen to have increased substantially in terms of usage since the onset of the financial crisis in 2007.

The evidence thus shows that the Eurosystem's collateral framework favors illiquid and bank-issued collateral. This is also the collateral with the highest incidence of theoretical prices in the determination of collateral values. So the collateral framework of the ECB appears to be set up to circumvent market forces. In other words, it is a policy tool. The increased usage of bank-issued collateral after the onset of the financial crisis suggests that one such policy is to provide support to banks. This may help iron out problems in the short run, but is not necessarily optimal as a day-to-day policy over a long period.

Central bankers sometimes refer to "channeling liquidity where it is needed" to justify a bias toward illiquid and bank-issued collateral, and a lack of market forces, in the collateral framework. However, when market forces are circumvented, other forces will come into play. In an arena as highly politicized as the euro, one of these forces could be politics, as argued by Nyborg (2016). Another force could be lobbying by specific players. In the Introduction, I touched on the idea articulated by Nyborg (2016) that a collateral framework that favors illiquid assets may lead to distortions in the real economy. Next, I examine this more closely in the context of a theoretical model.

4. Theoretical discussion

This section explores some of the ideas touched on above through the use of a simple theoretical model. The idea I wish to focus on is that collateral policy may influence financial stability. I therefore employ the canonical setup of Diamond and Dybvig (1983) to allow financial fragility to be understood in a familiar way as a run on entities that provide liquidity through maturity transformation, with the limits that this may also involve. In turn, maturity transformation is a response to market incompleteness. I refer to maturity transforming institutions as banks, for short, and to a financial system, or economy, as being bank-oriented if liquidity is (primarily) provided in this way. I contrast a bank-oriented system with an intermediated market-oriented system. Jacklin (1987) shows that mutual funds, combined with trading in the market, may perform as well as banks in a Diamond and Dybvig economy, but without the drawback of runs. He also shows that the performance of such intermediated markets may be less good if agents have “smooth” preferences. However, the setup with smooth preferences is arguably less interesting from the perspective of financial fragility since such preferences dilute the effects of liquidity shocks and runs. Thus, I wish to take the debate in a different direction and focus on the underlying technology that is used to provide *real* liquidity in the economy instead.

A point that emerges is that the credibility of the intermediated-markets solution is a function of the underlying technology through which real liquidity is produced. Furthermore, there may be a feedback loop between the financial system (with respect to liquidity provisioning) and available technologies. In turn, I argue that this is influenced by a central bank's collateral policy.

One of my objectives is to understand the implications of different technologies in order to understand the incentives created by them in a larger game that one would reasonably expect the simple Diamond and Dybvig style model to be embedded in. In particular, any large provider of liquidity or capital has substantial power over what kinds of technologies can be developed and funded. That banks are significant providers of liquidity and funding gives them substantial power over this process. In addition, the crucial role played by banks in the monetary system gives them additional influence over the technologies that are available in the economy. For example, they may have exert influence over the central bank's collateral policy (along the lines of standard “regulatory capture” style arguments).

The evidence presented above suggests that the central bank (in the euro area) favors illiquid bank-issued collateral in its collateral policy. The model I analyze here provides a perspective for understanding the implications. It points to such favoritism strengthening banks and, at the same time, brewing fragility. It also stifles innovation.

Diamond and Dybvig's model is real, rather than nominal, and I follow this approach. This may be viewed as a shortcoming because banks obviously deal in nominal rather than real contracts. However, one may view this approach as allowing the analysis of the real consequences of financial failure in a simple way. The notion is that bank runs and, more generally, financial system failure, have real effects. If not, these events are inconsequential and no further thought needs to be given to them. By modelling a real economy directly, one loses details of the exact transmission mechanism from financial failure to the real economy, but it makes it easier to gain broader insights with respect to the role of the provisioning of real liquidity. I discuss issues relating to modelling the nominal aspects of financial intermediation after the real model is laid out and analyzed. My discussion in this section is meant as an exploration of what is a complicated topic rather than an analysis of an all-inclusive, closed model. The objective is to raise some issues, stimulate to debate, and to provide a setting that can be linked to the evidence on euro-area collateral policy presented above.

4.1 Baseline model

The baseline model is that of Diamond and Dybvig (1983), which I briefly review. There are three dates, $t = 0, 1, 2$ and a continuum of households (with unit mass). Each household seeks to maximize expected utility from consumption at dates $t = 1, 2$, based on the returns from investments at date 0 (to be described). Households learn at date 1, whether they have a preference for "early" (date 1) or "late" (date 2) consumption. The probability of wanting to consume early is $\lambda \in (0, 1)$. The interpretation is that households receive a "liquidity shock" with probability λ. A household's preferences are thus given by

$$U(c_1, c_2) = \begin{cases} u(c_1) & \text{if the household receives a liquidity shock at date 1} \\ \rho u(c_2) & \text{otherwise,} \end{cases} \tag{2}$$

where c_t is consumption at date t, $\rho \in (0, 1)$, and $u(\cdot)$ is a strictly increasing and strictly concave function, satisfying the Inada conditions and having relative risk aversion not less than one. Consumption good can be costlessly stored from date 1 to date 2. Expected utility is $EU(c_1, c_2) = \lambda u(c_1) + (1 - \lambda)\rho u(c_2)$. For simplicity, I will often work with $u = log$. This facilitates the derivation of explicit expressions of various variables of interest. While the basic insights from the analysis do not depend on this assumption, some specific details do and will be pointed out.

Liquidity shocks are independent across households so that, while there is individual uncertainty, there is no aggregate uncertainty. Households choose consumption after they observe whether they are shocked, i.e., after the uncertainty with respect to their preferences is revealed. The shocks are households' private information, implying that a market solution with state-contingent contracts cannot emerge.

Each household has a date 0 endowment of one unit of a *production* good. This can be invested in the technologies available in the economy to yield date 1 and date 2 returns in terms of *consumption* good. The technology considered by Diamond and Dybvig can be defined by the structure of ordered pairs $\{(1,0) \vee (0,R)\}$ such that per unit of input, it yields either one unit of consumption good at date 1, $(1,0)$, OR R units at date 2, $(0,R)$. It is assumed that $\rho R > 1$. The technology can be interpreted as a long-term technology that can be liquidated at date 1 for a unit return. It could also be viewed as a "safe" investment that has an upside if output is foregone at date 1. More generally, it can be viewed as bundling the separate technologies $\{(1,0)\}$ and $\{(0,R)\}$.

My point of departure from the basic Diamond and Dybvig setup relates to the set of available technologies. In the baseline model, I consider a family of Diamond-Dybvig style bundled technologies, Θ, with elements θ such that returns can be described by the structure $\{(l_\theta,0) \vee (0,R_\theta)\}$. It is assumed that $l_\theta < 1$, $R_\theta > R$, and $\lambda l_\theta + (1-\lambda)R_\theta = \overline{R}$. Thus, the technologies give the same expected rate of return (viewing λ as the probability of liquidation), but differ according to risk, or illiquidity. Without loss of generality, technologies can be ranked such that $\theta' < \theta$ implies $R_{\theta'} < R_\theta$ (and $l_{\theta'} > l_\theta$). Technologies with higher θ have larger long-term returns, but lower liquidation values. In this setup, $l_\theta = 1$ is simply a normalization representing the least risky, or illiquid, technology. I will denote this by θ_0.

For a given θ, first best cannot be achieved through a direct, household-to-household market. There are no gains to trade. However, Diamond and Dybvig (1983) show that it can be achieved through a bank offering deposit contracts. As shown by Jacklin (1987), a potential problem with this solution is that it is undone if a forward market in consumption good opens up at date 1. This creates an arbitrage opportunity that households can take advantage of by not depositing their endowments at the bank at date 0. Equilibria with consumption levels between first best and autarky can be generated in setups with market frictions or regulation, as studied, for example, by Allen and Gale (2004) and Farhi, Golosov, and Tsyvinski (2009). To keep the focus on the underlying technology through which real liquidity is provided, I rule out household-to-household trade in deposits and long-term investments at the interim date. This could be motivated by the existence of moral hazard or adverse selection in household-run long-term projects.[19]

[19] Jacklin's (1987) arbitrage trade involves the "deviating" household holding on to its long-term investment if the household does not receive a liquidity shock and trading the project for date 1 consumption

The first set of questions to be addressed below are: what are the properties of first best under the different θ-technologies, which technology is preferred by households, and which is likely to emerge in the economy? The idea behind the last question is that forces (outside the specific model) may influence what technologies are developed. For example, the collateral framework may be biased in favor of specific technologies (on purpose or inadvertently) and influence may be wielded by banks or other players.

4.2 Baseline analysis

For a given technology, θ, first best is the solution to the following maximization problem

$$\begin{aligned} \max_{c_1,c_2} \quad & \lambda u(c_1) + (1-\lambda)\rho u(c_2) \\ \text{s.t.} \quad & \lambda c_1 = L l_\theta \\ & (1-\lambda)c_2 = R_\theta(1-L), \end{aligned} \tag{3}$$

where L is the fraction of the initial investment that is liquidated at date 1. The two constraints can be combined into

$$\begin{aligned} & (1-\lambda)c_2 = R'_\theta(l_\theta - \lambda c_1), \\ & \text{where } R'_\theta \equiv R_\theta / l_\theta. \end{aligned} \tag{4}$$

The first-order condition is the standard expression

$$\frac{u'(c_1^*(\theta))}{u'(c_2^*(\theta))} = \rho R'_\theta, \tag{5}$$

where $c_t^*(\theta)$ is the first-best consumption level at date t given technology θ. Since $\rho R > 1$ (by assumption), $\rho R'_\theta > 1$ and so $c_2^*(\theta) > c_1^*(\theta)$. The assumption on relative risk aversion ensures an interior solution $l_\theta < c_1^*(\theta) < c_2^*(\theta) < R_\theta$. Without some structure in place (e.g., a bank), autarky would ensue, with households consuming l_θ at date 1 if they receive the liquidity shock or R_θ at date 2 if they do not.

Diamond and Dybvig show that first best can be achieved through intermediation whereby a bank offers deposit contracts that pay off $c_1^*(\theta)$ at date 1 OR $c_2^*(\theta)$ at date 2. For this to work, it is important that $c_1^*(\theta) \leq c_2^*(\theta)$ so that non-shocked households do not

if the household receives a liquidity shock. The latter may be untenable if the long-term return requires unobserved household effort/maintenance, or if there are issues regarding idiosyncratic shocks to individual projects. Gorton and Pennacchi (1990) explore this idea more fully.

prefer to withdraw their deposits at the interim date (and store the consumption good until date 2).

The banking solution comes with financial fragility in that there is also a bank-run equilibrium in the subgame that starts after banks have invested date 0 capital. In this equilibrium, all households withdraw, resulting in the inefficient liquidation of the long-term project and suboptimal consumption levels.[20] If this is the equilibrium that will be played in the banking subgame, banking will not occur in the first place. So if the run is anticipated, autarky will result.

While the structure of the setup means that there is one or the other equilibrium, as suggested by Diamond and Dybvig (1983) one may think of the "good" equilibrium as representing a situation where a bank run at the interim stage will result with some low probability. As long as it is sufficiently low, households will prefer to give their assets to the bank rather than invest them autarkically. In my discussion here, I will not consider the details of a run, what might cause it, or how a small probability of a run might affect initial investment decisions. These issues are discussed by Diamond and Dybvig and in the large, ensuing literature (see, among others, Gorton, 1985; Postlewaite and Vives, 1987; Jacklin and Bhattacharya, 1988; Chari and Jagannathan, 1988; Allen and Gale, 1998; Diamond and Rajan, 2001 and 2005; Goldstein and Pauzner, 2005).[21] My primary objective is to derive the properties of the "good" banking equilibrium under different technologies and to draw out the implications for banking versus market-oriented systems. However, the fragility of banking is an important consideration since it means that if first best can be achieved through an intermediated markets-solution, this might be better than banking, since it would not come with the fragility inherent to a bank-oriented system.

Proposition 1. *Under log utility, first best is described by* $c_1^*(\theta) = l_\theta/[(1-\lambda)\rho + \lambda)]$ *and* $c_2^*(\theta) = \rho R_\theta/[(1-\lambda)\rho + \lambda)]$*. Thus,* $c_1^*(\theta) < c_2^*(\theta)$ *and*

1. $c_1^*(\theta) > l_\theta$ *and is decreasing in* θ *(or the illiquidity of the underlying technology).*

2. $c_2^*(\theta) < R_\theta$ *and is increasing in* θ*.*

[20]Studying this requires a full specification of what happens if the bank has insufficient funds to cover all demands for withdrawals. These details, which are laid out in Diamond and Dybvig (1983), are not essential for the discussion here and are therefore skipped. What matters for my discussion is merely that the bank-run equilibrium exists.

[21]See also the extensive discussion by Freixas and Rochet (2008) in their excellent textbook.

3. $\lambda c_1^*(\theta) + (1-\lambda)c_2^*(\theta)$ *is decreasing in* θ.

4. $EU(c_1^*(\theta), c_2^*(\theta))$ *is decreasing in* θ.

Proof: See the Appendix.

It is intuitive that households' welfare is decreasing in the illiquidity of the underlying technology. This is verified in the proposition under log utility. As illiquidity increases, households face consumption that is more volatile and at a lower average level. This translates into lower utility (item 4). An immediate corollary is that *households' preferred technology is the least illiquid technology,* θ_0*, ceteris paribus.*

If banks have influence over the technologies that emerge in the economy, it is interesting to ask what technology a bank would prefer in the context of the current model. To address this, I assume that the bank's profit (or rent) is increasing in the utility gain to households from the bank's services relative to the alternative of autarky. While households have a preference for the most liquid technology, θ_0, what they are willing to pay the bank may conceivably depend on the technology that is available.

To examine this, let $c_t^a(\theta)$ denote the autarkic consumption of a household with a preference to consume at date $t = 1, 2$. Because there would be no gains to trade at date 1, $c_1^a(\theta) = l_\theta$ and $c_2^a(\theta) = R_\theta$. Thus, a household's expected utility gain from placing its capital with the bank is

$$\pi(\theta) = EU(c_1^*(\theta), c_2^*(\theta)) - EU(l_\theta, R_\theta). \tag{6}$$

This ignores the effect of a bank fee on consumption levels. We can think of the fee as "small." This small fee is increasing in the utility gain if it is a fixed proportion of it. Thus, the bank seeks to maximize $\pi(\theta)$ through its choice of θ.

Proposition 2. *Given log utility, households' utility gain,* $\pi(\theta)$*, from banking relative to autarky is independent of the available technology,* θ.

Proof: See the Appendix.

Thus, the baseline model (under log utility) represents a situation where the bank is neutral with respect to the technology that is developed. So the bank has no incentive to influence things one way or another. In the baseline model, banks are "good." They solve the market incompleteness problem through maturity transformation and they have no incentive to inhibit the development of the best possible technology, which here is $\{1, 0) \vee (0, R)\}$. Ignoring the specific role of log utility, the broader objection to these conclusions is that they are built on the premise that all potential technologies are of the "bundled" type represented by Θ.

4.3 Liquid technologies and intermediated markets

In an important contribution, Jacklin (1987) shows that first best can also be obtained through intermediated markets, whereby households place their capital in a mutual fund (or joint stock company). The fund pays a dividend of the first-best level of aggregate consumption good at the interim date. Households trade dividends for ex-dividend shares at the interim date to reallocate consumption good to first-best individual levels. Below, I review the argument. I make a small modification to the Diamond and Dybvig (1983) setup used by Jacklin. In particular, I assume that there is also a short-term, liquid technology that yields l_θ at date 1 and nothing at date 2, $\{(l_\theta, 0)\}$. Bhattacharya and Gale (1987) also discuss the intermediated-markets solution in a setup with completely unbundled technologies, $\{(1, 0)\}$ and $\{(0, R)\}$. The basic argument does not depend on how unbundled the technology is. However, I argue below that the intermediated-markets solution is not credible without the availability of the liquid technology.

If households' endowments at date 0 are in consumption good, one could interpret the liquid technology simply as storage. However, to link the analysis to the real economy, it is arguably more reasonable to interpret date 0 endowments as production good. In this case the liquid technology is not storage. It is something that ultimately has to be developed in the economy and may be promoted through the collateral framework.

The maximization problem is still given by (3), but L now combines the quantity of the long-term investment liquidated at date 1 with the investment in the short-term technology. The same banking solution as in the previous subsection yields first best. The only difference is that the bank may also invest in the liquid technology. But it is not necessary for it to do so, nor does it come with any advantage to the bank.

4.3.1 Mutual fund

Suppose now that households invest their date 0 wealth with a mutual fund, which, in turn, invests L in the available short-term technology, $\{(l_\theta, 0)\}$, and $1 - L$ in the available long-term technology, $\{(l_\theta, 0) \vee (0, R_\theta)\}$. The mutual fund then pays out all interim income as a dividend, i.e., it pays a total dividend of Ll_θ. Households can subsequently trade ex-dividend shares in the mutual fund (date 2 consumption) for dividends (date 1 consumption) to reallocate consumption good according to their preferences, (2).

To clear the market at date 1, the price of date 2 consumption in terms of date 1 consumption must be

$$P(L;\theta) = \frac{(1-\lambda)Ll_\theta}{\lambda(1-L)R_\theta} = \frac{c_1}{c_2}. \tag{7}$$

So, at the first-best investment level in the short-term asset, $L^*_\theta = \lambda c_1^*(\theta)/l_\theta$, the market clearing price is $P^*_\theta = c_1^*(\theta)/c_2^*(\theta)$. Each ex-dividend share is a claim on $1-L$ units invested in a technology that yields R per unit at date 2. Hence, the ex-dividend market-clearing price per share at date 1 is

$$P^*_\theta(R_\theta) = \frac{(1-\lambda)L^*_\theta l_\theta}{\lambda} = \frac{c_1^*(\theta)}{c_2^*(\theta)} R_\theta(1 - L^*_\theta) \tag{8}$$

With this exchange rate between consumption at dates 1 and 2, will households be willing to trade at date 1? Consider first the case that the mutual fund is a closed-end fund so that investors cannot withdraw their shares and force the liquidation of their individual investments at date 1. In this case, liquidity-shocked households will trade at any price, since holding on to the shares until date 2 is without value to such households. With respect to non-shocked households, their willingness to trade depends on the alternative of storing the dividend received at date 1. If this can be stored (as is assumed), a household with a preference for consuming at date 2 will be willing to trade if the date 2 units it can buy at the interim date exceeds what it could get from storage. So trade occurs if $1/P(L;\theta) \geq 1$. This holds (given the investment L^*_θ) because $1/P^*_\theta = c_2^*(\theta)/c_1^*(\theta) > 1$.

So first best is implementable through an intermediated-market solution when the illiquid long-term Diamond and Dybvig style technology is complemented by a liquid, or short-term, technology $\{(l_\theta, 0)\}$.[22]

[22] Markets do not work in terms of reallocating consumption at the interim date if households were to invest separately into the long-term and short-term technologies. The reason is that each household would

Consider next an open-end fund. In this case, shocked households can force the liquidation of their individual investments. However, a household prefers to trade if the price per share, $P_\theta^*(R_\theta)$, exceeds what it can get from liquidating its share, $(1 - L_\theta^*)l_\theta$. This reduces to $c_2^*(\theta)/c_1^*(\theta) \leq R'_\theta$, which is satisfied under the assumptions of the model (which ensure that first best involves consumption smoothing relative to the autarkic outcome). The condition under which non-shocked households are willing to trade is the same as for closed-end funds.

Thus, first best can be achieved by both closed and open-end mutual funds. At date 0, all households agree to the dividend policy that yields first best, and this can be implemented through investing L_θ^* in the liquid, short-term technology and the remainder in the illiquid, long-term technology. A mutual fund that maximizes profits, or rents, at date 0 by maximizing utility to households, announces this investment and dividend plan. The dividend is credible because there is no better use for the returns from the liquid investment at date 1 than paying it out as a dividend.[23]

4.3.2 The limitations of the mutual fund solution

If the short-term technology $\{(l_\theta, 0)\}$ is not available, the mutual fund can announce the same first-best dividend plan at date 0, but this is now arguably less credible. First best now requires that the mutual fund liquidates the fraction L_θ^* of the illiquid, long-term technology at the interim date. The problem is that at date 1, shocked and non-shocked

act as a price-taker, thereby giving rise to a corner solution (see Freixas and Rochet, 2008). For markets to work, it is necessary that households pool their investments. As discussed by Jacklin (1987), an individual household may have an incentive to "cheat" through direct investment (in the long-term technology) if everyone else invests in the fund. This exploits the "smallness" of an individual household. This deviation does not work if the market at the interim date is in terms of dividends and shares, as assumed here. It could also be problematic in variations of the model where moral hazard or idiosyncratic shocks could reduce the long-term value of projects (see footnote 19). Finally, it also does not work if sufficient scale is required to invest, or if households lack direct access to the technology. In a model with a finite number of funds, deviations from first best may occur because there may be an element of quantity competition among the funds. However, as studied by Bhattacharya and Gale (1987), the existence of multiple banks also gives rise to deviations from first best because of similar types of issues. I abstract from these concerns here.

[23] In practice, funds specify the class of assets they invest in and even asset characteristics within the class (e.g., high yield). If $\lambda > 0.5$, shocked households may try to increase the dividend. See footnote 24.

households disagree as to the optimal dividend. Since the dividend is not locked-in by the investment plan, the dividend decision could be revisited and changed. This would result in deviations from first best.

In a simple one-share, one-vote situation either nothing would be liquidated ($\lambda < 0.5$) or a fraction larger than L^*_θ ($\lambda > 0.5$).[24] More generally, depending on bargaining powers (in Nash or sequential bargaining), any division of surplus is possible. It is reasonable to suppose that the group in the majority has superior bargaining power. Thus, if the new consumption plan is denoted by $(d_1(\theta), d_2(\theta))$, we would have a dividend that results in $d_1(\theta) < c^*_1(\theta)$ and $d_2(\theta) > c^*_2(\theta)$ if $\lambda < 0.5$, and the reverse if $\lambda > 0.5$. Under open-end funds, shareholders have the outside option to liquidate their individual shares, implying $d_1(\theta) \geq l_\theta$. The overall conclusion is that if only the illiquid, long-term technology is available, it is arguably not plausible that first best can be achieved by households having shares in a mutual fund.[25] So a bank-oriented financial system would have an edge.

Next, I consider a variation of the model where the liquidity shock itself is uncertain. Specifically, the liquidity shock (of λ) only materializes with a nontrivial probability q. I revert to the setup where the liquid technology is available (and $\lambda < 0.5$) so that a mutual fund is credible. First best (ex ante) now involves a more extreme consumption profile. If we denoted this by $(e^*_1(\theta), e^*_2(\theta))$, it is straightforward that $e^*_1(\theta) < c^*_1(\theta)$ and $e^*_2(\theta) > c^*_2(\theta)$. A mutual fund could be set up to yield this new profile.

However, banking could do better. Suppose the bank promises $(c^*_1(\theta), c^*_2(\theta))$ as before. If a shock does not materialize, no one will withdraw at the interim date, which also means that there is no liquidation at date 1. Since $c^*_2(\theta) < R_\theta$, there will be some "cream" left at date 2. This would be shared equally among depositors if the bank is a cooperative (mutual). Otherwise, it would accrue to the bank's shareholders. This also means that when there is a chance that there will be no liquidity shock at date 1, *the bank prefers utilizing the illiquid technology rather than a blend of the liquid and illiquid technologies.* This therefore strengthens the banks' incentive to push (outside of the model) for the illiquid technologies.

[24] If $\lambda > 0.5$, shocked households would optimally want to liquidate as much as possible subject to it being compatible with trade in ex-dividend shares. This yields $c_1 = c_2 = Ll_\theta/\lambda$, where $L = \lambda R'_\theta/[1 + (R'_\theta - 1)\lambda]$. This is also true if a liquid asset is available and invested in.

[25] Giving each household debt claim of $L^*_\theta l_\theta$ against the mutual fund and a non-dividend paying share would work in the same way as an all-equity mutual fund. Similar issues would arise.

While the analysis above shows that open-end and closed-end funds do equally well in the simple setup without aggregate uncertainty, the existence of aggregate uncertainty (and other frictions) may favor closed-end funds. Suppose, for example, that the liquidity shock could hit $\lambda_h > \lambda$ households with some positive probability, and that this is sufficiently large that affected households prefer to withdraw their funds rather than collect the dividend. Now, bad-faith equilibria can be constructed where households decide to redeem their funds before the shock is revealed if they receive a signal that the probability of λ_h has increased, and if they expect that their right to redeem their shares will be suspended (by a non-shocked majority). My point here is that the simple Diamond and Dybvig framework can be expanded to allow for the possibility of runs on open-end mutual funds (see also Bernardo and Welch, 2004). After the financial crisis, there has been renewed interest in the runnability of these funds (see, e.g., McCabe, 2010; Hannam, 2013; Schmidt, Timmermann, and Wermers, 2014; Zeng, 2016; and the references therein). The beginning of the financial crisis is often associated with BNP Paribas' announcement on August 9, 2007 that they were suspending redemptions for three of their money market funds (with exposure to US subprime loans, see footnote 8). Thus, my focus is on the tenability of closed-end funds.

In conclusion, an uncertain liquidity shock favors banks in the sense that the mutual fund solution leads to inefficient liquidation (seen from an ex-post perspective), if the liquidity shock does not materialize. On the other hand, the chance of a bank run, favors (closed-end) mutual funds. Thus, there may be a tradeoff. Mutual funds offer a more stable environment, but, when things go well, they are not as efficient as banks. So under aggregate uncertainty, a hybrid financial system with both banking and intermediated markets may be constrained-optimal. This would involve the availability of both short-term liquid and long-term illiquid technologies. However, the tradeoff suggested by the discussion here does not take into account that the available technologies are likely to be endogenous to the financial system.

4.4 Innovation

The analysis above shows that banks have an edge over mutual funds when the liquid technology is not available. Mutual funds work relatively better when there is a liquid, short-term technology. Thus, banks may have an incentive to try to stifle the availability of liquid technologies in the first place.[26] This may have broader implications.

If the θ-technologies can be partially unbundled so that the liquid technology $\{l_\theta, 0)\}$ is available for all θ, it is clear that the combination of $\{(l_\theta, 0)\}$ and $\{(l_\theta, R_\theta)\}$ is not optimal. Letting $\overline{\theta}$ be the maximum θ and $R_{\overline{\theta}}$ be the maximum long-term rate of return that is feasible to achieve, the optimal combination of a liquid technology and an illiquid, bundled technology is $\{(1, 0)\}$ and $\{(l_{\overline{\theta}}, R_{\overline{\theta}})\}$.[27] However, banks do not have an incentive to promote liquid technologies because these leave banks open to competition from mutual funds. Recall also from Proposition 2, that if there are only bundled technologies, then the preferred technology is $\{(l_{\theta_0}, 0) \vee (0, R_{\theta_0})\}$.

Thus, there are two potential losses to banking-driven financial systems as opposed to market-driven financial systems; (i) banking-driven systems are fragile, and (ii) innovation may be stifled. As discussed in the previous section, the advantage to banking is that it allows for a more flexible liquidation strategy if the liquidation shock is uncertain. In the model explored here, banking profits are best protected under bundled, illiquid technologies.

4.5 Hybrid financial systems

A way for the bank to attempt to stifle competition from markets is to lobby for measures that reduce the capacity of liquid technologies. This may give rise to the emergence of a hybrid financial system where banks co-exist with markets. As observed earlier, this may also result from a tradeoff between inefficient liquidations under intermediated markets and bank runs, when there is aggregate uncertainty. In the context of the model, this means that households funnel some of their capital at date 0 to a bank and the rest to a mutual fund. Verifying the feasibility and nature of a hybrid financial system is interesting regardless of whether capacity constraints to the liquid technology arise from banks' efforts to reduce competition.

To investigate this, consider first a setup without capacity constraints. In particular, suppose the efficient liquid technology, $\{(1, 0)\}$, is available, and that this is complemented with an illiquid, bundled technology $\{(l_\theta, 0) \vee (0, R_\theta)\}$. The maximization problem is as

[26] Although a bank could, in principle, operate a mutual fund, I am assuming here that the bank and the mutual fund are different entities.

[27] The completely unbundled combination $\{(1, 0)\}$ and $\{(0, R_{\overline{\theta}})\}$ has the same first-best consumption profiles.

in (3), but with the constraint changing to $(1-\lambda)c_2 = R_\theta(1-\lambda c_1)$. The difference as compared with the constraint in (3) is essentially that l_θ (in the constraint) is changed to 1. This reflects that it is optimal to provide interim liquidity provisioning from the liquid technology rather than from liquidating the illiquid θ-technology. Thus, the first-order condition is

$$\frac{u'(\hat{c}_1(\theta))}{u'(\hat{c}_2(\theta))} = \rho R_\theta. \tag{9}$$

Hats are used to indicate first best in this setup to distinguish it from the earlier one and the analysis with capacity constraints that follows. The optimal investment in the liquid technology is $\hat{L}_\theta = \lambda\hat{c}_1(\theta)$. It is straightforward that first best can be achieved, as before, through both banking and intermediated markets. Under log utility, first best is

$$\hat{c}_1(\theta) = 1/[(1-\lambda)\rho+\lambda] \qquad \text{and} \qquad \hat{c}_2(\theta) = \hat{c}_1(\theta)\rho R_\theta. \tag{10}$$

Next, consider the case that there is a capacity constraint on the liquid technology. In particular, suppose that the set of available technologies at date 0 consists of unconstrained capacity in the bundled technology $\{(l_\theta, 0) \vee (0, R_\theta)\}$, with $l_\theta < 1$, and constrained capacity in the liquid, short-term technology $\{(1,0)\}$. Given the capacity constraint, it is only possible to place a total of $S < \lambda\hat{c}_1(\theta)$ in the liquid technology, where $\hat{c}_1(\theta)$ is the first-best consumption level at the interim date when there is no capacity constraint (as above).

Given the available technologies, first best is the solution to the following maximization problem:

$$\begin{aligned} \max_{c_1,c_2} \quad & \lambda u(c_1) + (1-\lambda)\rho u(c_2) \\ \text{s.t.} \quad & \lambda c_1 = S + L l_\theta \\ & (1-\lambda)c_2 = R_\theta(1-S-L). \end{aligned} \tag{11}$$

Both constraints use the observation that since $S < \lambda\hat{c}_1(\theta)$, first best must involve investing S in the liquid technology.[28] The two constraints can be combined to form the following constraint

$$(1-\lambda)c_2 = R'_\theta(l_\theta + (1-l_\theta)S - \lambda c_1). \tag{12}$$

The first-order condition is given by Equation (5) rather than (9). This is a result of the capacity constraint. On the margin, it is the bundled technology, not the liquid one, that matters. Still, first best itself is different than in Subsection 4.2 because the constraint (12) is new, reflecting the availability of the liquid technology.

[28]First best in the unconstrained case involves investing $\lambda\hat{c}_1(\theta)$ in the liquid technology, since $l_\theta < 1$.

Under log utility, combining the first-order condition with the constraint yields

$$c_1^*(\theta) = \frac{l_\theta + (1 - l_\theta)S}{(1-\lambda)\rho + \lambda} \qquad \text{and} \qquad c_2^*(\theta) = \frac{l_\theta + (1 - l_\theta)S}{(1-\lambda)\rho + \lambda}\rho R'_\theta. \tag{13}$$

Both first-best consumption levels are increasing in S, which is intuitive. Households are better off as capacity in the liquid technology increases, because it is superior to the bundled θ-technology with respect to producing interim liquidity. With respect to interpreting the expressions in (13), it bears emphasis that they are derived under the assumption that $S \leq \lambda\hat{c}_1(\theta)$.

As always, first best is achievable through a bank. But this comes with the drawback of fragility, which motivates examining the possibility of a hybrid system. The most stable hybrid system is the one where the bank receives the smallest possible portion of households' capital at date 0. Thus, I am especially interested in whether the first-best consumption levels, (13), can be achieved in a hybrid system where the mutual fund receives enough capital to invest S in the liquid technology.

To address this, note first that a hybrid solution must involve the mutual fund also placing some capital in the illiquid, long-term technology. The first-best outcome requires that liquidity-shocked households receive the entire return from the liquid technology at the interim date. So the mutual fund will need to pay out all returns from its investment in the liquid technology at date 1 as a dividend. The fraction $1 - \lambda$ of households that are not shocked will have to trade their portion of these dividends with the fraction λ of households that are liquidity-shocked. In return, non-shocked households receive the shares of those that are shocked. For the non-shocked households to be content with this trade, there must be something left in the fund after the dividend has been paid. This something is x invested in the illiquid, long-term technology.

Clearly, x must be sufficiently large for the non-shocked households to be willing to trade. In contrast, non-shocked households are willing to exchange their units in the mutual fund at date 1 for dividends at any terms (with a positive implied price, as before).

With respect to the non-shocked households, note first that, given market-clearing trade, non-shocked households would receive shares with a claim on λx units in the illiquid, long-term technology in aggregate, yielding $\lambda x R_\theta$ units of consumption good at date 2. In return, they would give up $(1 - \lambda)S$ units of consumption good at date 1 that could be costlessly stored until date 2.[29] Thus, x must satisfy

$$x \geq \frac{1-\lambda}{\lambda}\frac{S}{R_\theta}. \tag{14}$$

A feasibility condition for the hybrid system is that the capital put into the liquid and illiquid technologies by the mutual fund sums to less than one, that is,

$$x + S < 1. \tag{15}$$

Now, let L_θ^* be the number of shares in the illiquid, long-term technology that is liquidated at the interim date under the first-best consumption plan, $(c_1^*(\theta), c_2^*(\theta))$. Clearly, $S + L_\theta^* < 1$. For an individual household, the amount of the first-best consumption at date 1 that comes from this liquidation is $w_1 \equiv L_\theta^* l_\theta = c_1^*(\theta) - S/\lambda$.

Define $\alpha \equiv 1 - S - L_\theta^*$. This is the quantity invested in the bundled technology that will be held until maturity under first best. Finally, define α' to be such that

$$\frac{\alpha' R_\theta}{1-\lambda} = w_1 = c_1^*(\theta) - \frac{S}{\lambda}. \tag{16}$$

Note that $\alpha' < \alpha$ since

$$\frac{\alpha R_\theta}{1-\lambda} = c_2^*(\theta) > c_1^*(\theta) > c_1^*(\theta) - \frac{S}{\lambda} = w_1.$$

As a result, if $x = \alpha - \alpha'$, the feasibility constraint (15) would be satisfied. With these preliminaries, we can establish the following result.

Proposition 3. *Suppose $u = \log$. First best can be implemented with a minimum level of fragility through the following equilibrium:*

1. *Each household invests $S + x < 1$ in the mutual fund, where*

$$x = \alpha - \alpha'. \tag{17}$$

   Households place the remainder of their capital in the bank. This is $1 - S - x = L_\theta^* + \alpha'$.

2. *The mutual fund invests S in the liquid technology, $\{(1, 0)\}$, and x in the bundled, illiquid technology $\{(l_\theta, 0) \vee (0, R_\theta)\}$.*

[29] I am assuming a closed-end fund so that shocked households' incentive compatibility condition for trading at the interim date is automatically satisfied.

3. *The bank places all units of capital it receives,* $L^*_\theta + \alpha'$, *in the bundled, illiquid technology. It promises to pay* $w_1 = L^*_\theta l_\theta = c^*_1(\theta) - S/\lambda$ *to withdrawers at date 1 and* $w_2 = w_1$ *to withdrawers at date 2. It achieves this by liquidating* L^*_θ *of the bundled technology at date 1 while holding* α' *to maturity at date 2.*

4. *Liquidity-shocked households withdraw their funds from the bank at date 1 and sell their ex-dividend shares in the mutual fund to non-shocked households for a price of* $(1-\lambda)S/(\lambda x)$ *per share.*

5. *At date 2, each non-shocked household withdraws* $w_2 = w_1$ *from the bank and collects dividends of* $xR_\theta/(1-\lambda)$ *from the mutual fund.*

Proof: See the Appendix.

In the equilibrium described in Proposition 3, banks and markets specialize in different forms of liquidity provisioning. Banks do maturity transformation, while mutual funds provide direct (and therefore more robust) liquidity through investment in the liquid technology. Disruption to the banking system will, therefore, especially affect investments in the illiquid, long-term technologies that banks specialize in.

An increase in the capacity of the liquid technology increases the potential share of liquidity provisioning that can take place via intermediated markets. This increases welfare through three "channels." First, it reduces the fragility of the financial system. Second, it allows liquidity to be produced more efficiently through the liquid, short-term technology. Third, it increases the potential for innovation. While Proposition 3 takes a given illiquid technology, θ, as given, the discussion in Subsection 4.4 shows that the potential for innovation increases when liquid technologies are developed. This is because households' preferred holdings change from the most conservative illiquid technology under banking to a mixture of the most efficient liquid technology and the most aggressive (highest long-term return) illiquid technology under intermediated markets (without capacity constraints). The latter combination increases consumption levels relative to the former. In general, as the capacity, S, in the liquid technology increases, households' preferred long-term technology becomes increasingly aggressive (θ increases) and overall productivity and welfare increases. The policy recommendation is, therefore, that liquid technologies should be promoted. This prescription appears to be at odds with Eurosystem collateral policy which is to favor illiquid and bank-originated collateral which is so illiquid that market prices, for the most part, do not exist.

4.6 Collateral and money

The model studied above is admittedly incomplete with respect to collateral frameworks. There is no specific modelling of money or eligible collateral. The contracts are real, being denominated in consumption good. Nevertheless, the model yields several insights. These are applicable to a more realistic setup with money and collateral to the extent that Diamond and Dybvig's model of intermediation captures relevant real-life phenomena. My perspective on their model is that it can be viewed as a shorthand for a more involved model that has both a real and a nominal sector. The model captures the idea that bank runs are disruptive to the real economy in a straightforward, parsimonious way.

The literature makes a distinction between runs on individual banks and full-fledged panics. A run on an individual bank does not necessarily lead to a systemic crisis. While Diamond and Dybvig's model is set up in terms of a single bank, the more general point is that maturity transformation is associated with fragility. This is as true for a broad system as it is for a single bank. Furthermore, as extensively studied in the literature, panics can be set off by runs on individual banks for a variety of reasons. One of these relates to Bhattacharya and Gale's (1987) point that liquidity is a public good and, therefore, the private provisioning of liquidity is a subject to a free-rider problem. Hence, when a bank (or a small group of banks) fails, liquidity may be tight in the economy, which can precipitate further runs. Thus, a general point of the analysis above is that the best way to reduce the incidence and amplitude of bank runs and runs on the financial system is to promote a system where real liquidity is generated more directly than through maturity transformation and banks play a smaller role. I argue that the collateral framework may have influence over this.

The importance of central banks' collateral policies relates to the need for central bank money in economic transactions in modern economies. If central bank money is provided against collateral backed by investments in technology θ' but not θ'', then technology θ' has a relative edge. More capital may be invested in θ', *ceteris paribus*, because the collateral framework tilts the playing field in its favor. Because financial claims against technology θ' can generate central bank money (nominal liquidity), their prices may be relatively high so that the cost of capital for technology θ' is relatively low. The logic relates to Amihud and Mendelson's (1986) insight that households with immediate liquidity needs optimally tilt portfolios toward liquid assets, which may inflate the prices of these assets relative to those of illiquid assets. Buiter and Sibert (2005) and Ashcraft, Gârleanu, and Pedersen (2010) argue that lowering haircuts in central bank repos causes the prices of the affected assets to rise. The impact of central bank collateral policy would be expected to be especially large under a full-allotment policy, since this implies an extreme increase in the ability of eligible collateral to generate central bank money directly from the central bank. A challenge with respect to testing this is that, as seen above, most eligible collateral do not have market prices.

Because of their role in the money creation process, banks have access to funds in a way that is different from that of other potential providers of funding. When a bank makes a loan, in practice, it also creates a liability in the form of a deposit. If eligible, the loan itself can be used by the bank vis-à-vis the central bank to obtain central bank money. (In the euro area, credit claims are eligible collateral.) This helps ease a bank's constraints on lending. The quantity of central bank money a bank needs against the loan is a function of the demand for banknotes, how, when, and where the funds will be spent, and the flow of funds within the domestic interbank system and between the domestic banking sector and external entities. Central bank money becomes increasingly important when the demand for banknotes increases, money flows out of the system, and the interbank market tightens. The monetary base typically drifts up as the economy expands, indicating that the quantity of money matters. Assets that can generate central bank money, by virtue of being eligible for purchase or as collateral in repos with the central bank, therefore have an advantage over other assets. Such assets may be "easier" to finance, and the more so the more generous the terms offered by the central bank are. Banks may be especially well placed to influence what these assets are and the terms of the exchange between collateral and central bank money by virtue of their close links with the central bank. This may be relevant with respect to understanding why bank-originated collateral makes up the largest portion (by ISIN count) of eligible collateral in the Eurosystem.[30]

[30]Central banks are also set up to support the State (society). They are governments' banks. Thus, government bonds also constitute an important segment of eligible collateral. As seen in Figure 4, this is the most significant segment, by value, in the euro area.

Models of intermediation in the Diamond and Dybvig (1983) tradition that incorporate nominal contracts include Champ, Smith, and Williamson (1996), Allen and Gale (1998), Cooper and Corbae (2002), Diamond and Rajan (2006), Skeie (2008), and Allen, Carletti, and Gale (2014). The general message from these models is that nominal contracts improve stability. But this relies on a number of very specific assumptions. Skeie (2008) is especially interesting with respect to the current paper because his model is essentially that of Diamond and Dybvig, but with a nominal sector. He also modifies the set of available technologies to include a liquid, short-term technology. In his model, this is simply costless storage, because the date 0 endowment is in consumption good. In Skeie's model, bank runs are eliminated. The mechanism that prevents runs works through the price system. If non-shocked households withdraw early, the extra purchasing power in the economy merely drives the price of consumption good up at the interim date. Households who keep their money in the bank and save until date 2 are left with less competition for goods and are actually better off. Some of the key assumptions used to generate this result are: (1) Prices are fully flexible. (2) The economy is a "closed loop." Money cannot be taken to other markets. (3) No input is required at date 1 to generate superior long-term returns at date 2. This is a result of the straight adoption of the technology utilized by Diamond and Dybvig (1983). (4) Central bank money, which is only used at date 0 before inside money takes over, is freely available. Allen, Carletti, and Gale's (2014) efficiency result also relies on these assumptions, but with central bank money being used at all dates, not just date 0. One may view these models as setting benchmarks, but it is difficult to reconcile their "benchmark message" with the idea that bank runs and financial panics occur and cause disruptions to the real economy.

The idea that disturbances to the financial system spill over to the real sector is based not only on the notion that depositors' withdrawals bring about the liquidation into consumption good of long-term projects, although this serves as a convenient modelling device in Diamond and Dybvig (1983). It is also based on the idea that bank runs hinder the flow of capital from less productive to more productive use. This relates to point (3) above. Consider a Diamond-Dybvig style setup where production good is required at the interim date for high long-term returns to materialize. For example, crops require irrigation and fertilizer to reach their potential. Most production processes require labor throughout. If households have date 1 endowments of production good, they may choose to withhold this at the interim date if they fear that others will do so or that it will be put to inefficient or ill use. At the same time, they withdraw their money from their bank because they understand that withholding production good will result in low returns to firms in the economy, ultimately leading to defaults and making it difficult for the bank to honor deposits. In this scenario, a bank run would be associated with an interruption of the production process defined more in terms of *entry* than Diamond and Dybvig style *exit*.

The efficiency results of the nominal banking models also rely on a super-accommodative central banks (point 4 above). However, as discussed by Buiter and Sibert (2005), Cao and Illing (2011), and Nyborg (2016) this can create moral hazard. The works of Kiyotaki and Moore (2003) and Holmström and Tirole (2011) emphasize that outside money may be necessary to deal with moral hazard from the originators of inside money. But the provisioning of central bank money may itself be subject to moral hazard. Central bank collateral frameworks are meant to deal with such realities. They are traditionally viewed as risk management tools. When collateral frameworks fail in this respect, the economy may be adversely affected. My analysis in the previous subsections represents just one channel through which this may occur. Other considerations include reduced incentives for banks to monitor (Nyborg, 2016).

5. Concluding remarks

This paper discusses the role of central bank collateral policy with respect to financial stability. Collateral policy is a significant, but not much studied, tool in a central bank's toolkit and an integral part of monetary policy. Its importance stems from the fact that it determines the type of collateral against which central bank money is issued and on what terms. The paper provides evidence that the Eurosystem's collateral framework sidesteps market forces. This supports the view I have put forth in other work, (Nyborg 2015 and 2016), that collateral policy in the euro area impinges on market discipline. By itself, this might be viewed as a source for concern with respect to financial stability. Market discipline is the third pillar of the Basel regulatory framework. Moreover, Fecht, Nyborg, Rocholl, and Woschitz (2015) show that banks in the euro area arbitrage the system set up by the central bank to deliver the worst possible collateral and credit risk to the central bank. This simultaneously undermines market discipline and weakens the central bank's balance sheet.

In this paper, I take the debate in a different direction, focusing on the tension between bank versus intermediated-market oriented financial systems. This may be influenced by a central bank's collateral policy. Bank-dominated financial systems are good at providing liquidity through maturity transformation, but have the drawback of fragility; they are prone to runs and panics. In contrast, financial systems characterized by intermediated markets provide liquidity through direct investments in liquid assets. My analysis suggests that this also promotes innovation, leading to higher welfare through two effects; (i) higher consumption levels when things go well, and (ii) a more stable financial system and economy. The implication is that the development of liquid technologies should be encouraged. The central bank can do this by promoting liquid assets through its collateral framework.

This prescription stands in sharp contrast to the policy pursued by the Eurosystem, where illiquid collateral is favored through an accommodative "channel liquidity where it is needed" policy. Such a policy supports and expands the role of banks, but represses markets and reduces welfare. The favoring of bank paper in the Eurosystem's collateral framework can also be seen by (i) the very large number of covered and uncovered bank bonds on the public list of eligible collateral, even including (ii) a very large number of unsecured bank bonds trading on non-regulated markets. The bias toward banks is also seen from the fact that credit claims and other non-marketable assets are accepted as collateral in the Eurosystem's operations. In 2015, the ECB advanced this further by allowing banks to put together non-marketable packages of credit claims, DECCs (see, Nyborg, 2016, and ECB, 2015/27 and 2015/34, for discussion and details).[31] The promotion of illiquid collateral at the expense of liquid collateral can be viewed as having the effect of decreasing the capacity of the liquid technology in my theoretical analysis. Thus, promoting illiquid collateral leads to a relatively large banking sector and, as a consequence, a more fragile financial system and a less innovative economy.

The collateral framework may work as a coordination device for banks to sustain a banking-oriented financial system. In an environment with many competing banks, they may be driven through the forces of competition to support larger capacities in the liquid technology required for a market solution with respect to the provisioning of liquidity. But this would undermine banks. A collateral framework that is biased toward illiquid and

[31]DECCs are "debt instruments backed by eligible credit claims."

bank-originated collateral provides a counterforce to the march of the markets, thereby helping to maintain banks' profitability and economic and societal power.

As in most of the banking literature, the focus of my theoretical discussion in this paper is on *real* liquidity. A liquid technology in my theoretical discussion can be thought of either as a production process that generates short-term real flows with great certainty, or as a security that pays out cash flows with great reliability over a short time frame. Securities that produce steady returns in good times through roll-over are not liquid in this sense. To be liquid, in the sense of this paper, a security must pay out reliable cash flows to its holders without having to be rolled over. My paper suggests that the construction and promotion of such securities could be a catalyst for a more stable financial system.

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Appendix: Proofs

Proof of Proposition 1

Using $u = \log$ in (5) yields $c_2^*(\theta) = c_1^*(\theta)\rho R'_\theta$. Substituting this expression in to the constraint in (3) and rearranging yields the expressions for $c_1^*(\theta)$ and $c_2^*(\theta)$ in the statement of the proposition. It is seen that $c_1^*(\theta) < c_2^*(\theta)$ since $l_\theta < 1 < \rho R < \rho R_\theta$. Numbered items 1 and 2 follow by the definitions of l_θ and R_θ and from the assumption that $\rho \in (0,1)$. Item 3: Substituting in the expressions for $c_1^*(\theta)$ and $c_2^*(\theta)$ yields

$$\lambda c_1^*(\theta) + (1-\lambda)c_2^*(\theta) = \frac{\lambda l_\theta + (1-\lambda)\rho R_\theta}{(1-\lambda)\rho + \lambda}.$$

To establish that this is decreasing in θ, one needs to show that the numerator in the RHS is decreasing in θ. Now, by assumption, $\lambda l_\theta + (1-\lambda)R_\theta = \overline{R}$. Thus, we can associate the technology θ with a positive real number such that $R_\theta = \overline{R} + \theta$ and $l_\theta = \overline{R} - \theta(1-\lambda)/\lambda$. It follows that

$$\lambda l_\theta + (1-\lambda)\rho R_\theta = \lambda \left[\overline{R} - \theta\frac{1-\lambda}{\lambda}\right] + (1-\lambda)\rho[\overline{R} + \theta] = \overline{R} - (1-\lambda)\theta(1-\rho).$$

This is decreasing in θ since $\rho \in (0,1)$. This establishes item 3. Item 4 follows directly from the previous items by the strict concavity of $u(\cdot)$. □

Proof of Proposition 2

Suppose $u = \log$. Using the expressions for $c_1^*(\theta)$ and $c_2^*(\theta)$ in Proposition 1, we have

$$EU(c_1^*(\theta), c_2^*(\theta)) = \lambda \log\left(\frac{l_\theta}{(1-\lambda)\rho + \lambda}\right) + (1-\lambda)\log\left(\frac{\rho R_\theta}{(1-\lambda)\rho + \lambda}\right).$$

Under autarky, $c_1^a(\theta) = l_\theta < c_1^*(\theta)$ and $c_2^a(\theta) = R_\theta > c_2^*(\theta)$. Hence, autarkic utility is

$$EU(c_1^a(\theta), c_2^a(\theta)) = \lambda \log(l_\theta) + (1-\lambda)\log(R_\theta).$$

The utility gain to a household from the services of the bank (promising first-best withdrawal terms) is, therefore,

$$EU(c_1^*(\theta), c_2^*(\theta)) - EU(c_1^a(\theta), c_2^a(\theta)) = -\log((1-\lambda)\rho + \lambda) > 0.$$

where the inequality follows from $\rho \in (0,1)$. As seen, the utility gain is independent of θ, which establishes the proposition. □

Proof of Proposition 3

By design, the structure described in Proposition 3 results in first-best consumption levels $(c_1^*(\theta), c_2^*(\theta))$ for each household. What remains to be shown is that condition (14) is satisfied and that the bank is drawn down at date 2. Note first that non-shocked households have no incentive to withdraw funds from the bank at date 1 since $w_2 = w_1$. Now, by definition, the funds left in the bank at date 2 per household is $\alpha' R_\theta/(1-\lambda) = w_1 = w_2$. Thus, the bank is drawn down at date 2.

Furthermore, since $w_2 = w_1$, we have

$$c_2^*(\theta) = w_1 + \frac{xR_\theta}{1-\lambda} = c_1^*(\theta) - \frac{S}{\lambda} + \frac{xR_\theta}{1-\lambda}.$$

Hence,

$$\frac{S}{\lambda} = \frac{xR_\theta}{1-\lambda} - (c_2^*(\theta) - c_1^*(\theta)).$$

It follows that

$$\frac{xR_\theta}{1-\lambda} > \frac{S}{\lambda},$$

since $c_2^*(\theta) > c_1^*(\theta)$ by log utility and $\rho \in (0,1)$. Thus, condition (14) holds. □

Table 1: Consolidated Eurosystem balance sheet (asset side, in billion EUR)

The table shows the asset side of the Eurosystem consolidated balance sheet and its percentage of euro-area GDP (Assets/GDP). Data sources: For balance sheet, `www.ecb.europa.eu/press/pr/wfs/2014/html/index.en.html` till 2013 and `www.ecb.europa.eu/pub/annual/balance/html/index.en.html` for 2014 and 2015. For euro-area GDP, Eurostat (`http://ec.europa.eu/eurostat/en/web/products-datasets/-/NAMA_GDP_C`), downloaded on May 29, 2016. For eligible marketable collateral, `www.ecb.europa.eu/paym/coll/charts/html/index.en.html`.

	Assets	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Gold and gold receivables	116.5	117.1	126.8	130.9	130.2	125.7	148.1	174.0	184.5	219.8	238.1	334.4	419.8	479.1	343.9	343.6	338.7
2	Claims on non-euro area residents denominated in foreign currency	254.9	258.7	264.6	248.6	189.5	153.8	152.0	147.0	137.6	152.8	191.9	220.2	236.8	258.0	245.7	270.3	307.1
3	Claims on euro area residents denominated in foreign currency	14.4	15.8	25.2	19.9	18.0	17.0	24.0	22.9	35.7	221.4	31.7	26.0	95.4	33.7	23.0	27.9	31.1
4	Claims on non-euro area residents denominated in euro	4.8	3.7	5.7	4.0	6.0	6.8	9.3	11.6	13.6	8.9	15.7	19.1	26.0	19.1	19.5	18.9	20.2
5	Lending to euro area credit inst. (monetary pol. op.) den. in euro	250.1	268.6	203.6	236.6	276.0	345.1	404.0	441.5	617.1	829.6	728.6	513.1	879.1	1,122.3	717.1	630.3	559.0
6	Other claims on euro area credit institutions denominated in euro		0.6	0.5	0.1	0.7	3.8	3.5	10.8	23.8	54.8	25.8	42.0	95.0	208.3	75.0	60.0	107.9
7	Securities of euro area residents denominated in euro	23.5	26.0	28.0	33.1	54.1	70.2	94.4	78.0	97.2	120.8	329.5	459.6	610.6	585.2	586.1	590.3	1,161.2
8	General government debt denominated in euro	59.2	57.7	68.7	66.3	42.9	41.3	40.3	39.9	37.1	37.5	36.2	35.0	33.9	30.0	28.3	26.7	25.1
9	Other assets	79.8	87.0	91.5	93.1	117.8	120.4	144.1	216.7	326.3	375.9	254.9	276.9	336.6	275.4	246.8	240.3	230.8
	Total assets	803.2	835.1	814.7	832.6	835.2	884.2	1,019.7	1,142.3	1,473.0	2,021.5	1,852.5	1,926.2	2,733.2	3,011.2	2,285.4	2,208.2	2,781.1
	Consolidated Eurosystem balance sheet as a percentage of euro-area GDP																	
	GDP	6,257	6,581	7,016	7,256	7,466	7,772	8,048	8,455	8,938	9,162	8,907	9,153	9,424	9,483	9,579	–	–
	Assets/GDP	13%	13%	12%	11%	11%	11%	13%	14%	16%	22%	21%	21%	29%	32%	24%	–	–
	Value of eligible marketable collateral (in billion EUR)																	
							7,647	8,217	8,737	9,387	10,941	12,828	13,677	12,751	13,719	14,183	13,952	13,653

Table 2: Haircuts and liquidity categories from May 1, 2015
(The information in this table was still in force as of June 8, 2016)

This is taken from Nyborg (2016), which itself is based on the General collateral framework document ECB (2014/60) and, where indicated, on General framework updates from ECB (2015/35). Steps 1, 2, and 3 refer to the Eurosystem's harmonized rating scale, which is available on its webpage (`www.ecb.europa.eu/paym/coll/risk/ecaf/html/index.en.html`) (but with some exceptions relating to the admissibility of short-term ratings as discussed in Nyborg, 2016, Table A.3). Features in the table that are from the Temporary framework are indicated in (light blue) italic type with a double dagger, ‡ (see ECB, 2013/36; and ECB, 2014/31). [a] *Except ABSs backed by residential mortgages or loans to SMEs issued before June 20, 2012 that do not fulfill certain standard eligibility criteria, but have a credit quality of at least BBB−. These have a haircut of 22%.‡*

		Haircut categories for marketable assets								
		Category I Debt instruments issued by central governments, ECB debt certificates, Debt certificates issued by NCBs prior to the date of adoption of the euro in their respective Member State		***Category II*** Debt instruments issued by local and regional governments, Debt instruments issued by entities classified as agencies by the Eurosystem, Debt instruments issued by multilateral development banks and international organisations, Jumbo covered bonds		***Category III*** Traditional covered bonds and other covered bonds, Debt instruments issued by non-financial corporations		***Category IV*** Unsecured debt instruments issued by credit institutions, Unsecured debt instruments issued by financial corporations other than credit institutions		***Category V*** Asset-backed securities[a]
Credit quality	Residual maturity (years)$^{(1)}$	fixed coupon	zero coupon	fixed coupon	zero coupon	fixed coupon	zero coupon	fixed coupon	zero coupon	
Steps 1 and 2	[0-1)	0.5	0.5	1.0	1.0	1.0	1.0	6.5	6.5	10.0
	[1-3)	1.0	2.0	1.5	2.5	2.0	3.0	8.5	9.0	
	[3-5)	1.5	2.5	2.5	3.5	3.0	4.5	11.0	11.5	
	[5-7)	2.0	3.0	3.5	4.5	4.5	6.0	12.5	13.5	
	[7-10)	3.0	4.0	4.5	6.5	6.0	8.0	14.0	15.5	
	[10,∞)	5.0	7.0	8.0	10.5	9.0	13.0	17.0	22.5	
Step 3	[0-1)	6.0	6.0	7.0	7.0	8.0	8.0	13.0	13.0	*22.0*‡
	[1-3)	7.0	8.0	10.0	14.5	15.0	16.5	24.5	26.5	
	[3-5)	9.0	10.0	15.5	20.5	22.5	25.0	32.5	36.5	
	[5-7)	10.0	11.5	16.0	22.0	26.0	30.0	36.0	40.0	
	[7-10)	11.5	13.0	18.5	27.5	27.0	32.5	37.0	42.5	
	[10,∞)	13.0	16.0	22.5	33.0	27.5	35.0	37.5	44.0	

Table 2 – continued from previous page

Floating rate debt instruments: Haircut applied to marketable debt instruments included in categories I to IV is that applied to zero-to-one-year maturity buckets of fixed coupon instruments in liquidity and credit quality step to which the instrument is assigned.
ABSs, covered bonds and unsecured debt instruments issued by credit institutions that are theoretically valued: Subject to an additional valuation haircut in the form of a valuation markdown of 5%.
Own-use covered bonds: Subject to an additional valuation haircut (markdown) of (a) 8% for own-use covered bonds in credit quality steps 1 and 2, and (b) 12% for own-use covered bonds in credit quality step 3. Note 1: " '[O]wn-use covered bonds' means covered bonds issued by either a counterparty or entities closely linked to it, and used in a percentage greater than 75 % of the outstanding notional amount by that counterparty and/or its closely linked entities." (ECB, 2014/60). Note 2: The statement in Note 1 was removed in ECB (2015/35), effective from January 25, 2016.
Debt instruments issued by credit institutions and traded on non-regulated markets: same haircuts as for other marketable assets.
Marketable assets denominated in foreign currency (yen, pounds sterling, and US dollars)*: there is an additional haircut which is applied in the form of a valuation markdown before applying the regular haircut. Valuation markdowns are as follows: Pounds sterling and US dollars: 16%; Yen: 26%.*‡ (ECB, 2014/31)

Table 3: Price source and availability

This table reports on pricing sources and availability in Bloomberg for all ISINs on the public list of eligible collateral from December 11, 2014, to May 3, 2016.* Each day, the fraction of ISINs (by count) in the indicated categories is calculated. Averages within categories are then taken over the sample period and reported (as an average percentage) in the table. So all reported numbers are in percent, except for those in the last column which reports on the average number of securities on the public list for each indicated category. The column labelled "All" provides the distribution of ISINs across liquidity categories (Panel B) and countries (Panel C). For the columns under the heading "Pricing Source and Availability:" For each ISIN, the pricing source is either based on specific pricing information ("market") or estimated by a model ("theoretical"). ISINs are labelled as having a theoretical price if they are labelled as such in Bloomberg (through the flag, BVAL), not found in Bloomberg, or are in Bloomberg without a price or pricing source. ISINs are labelled as having a market price, if the pricing-source flag in Bloomberg is one of BGN, EXCH, TRAC, or LCPR. BGN is a market consensus price for corporate and government bonds as determined by Bloomberg. Where executable quotes (limited executable prices) are available, BGN provides an indication of the executable market (indicative price level). EXCH flags indicative prices from exchanges. TRAC is the acronym for TRACE, which is FINRA's Corporate and Agency Bond Price Dissemination that reports OTC secondary market transactions in eligible fixed income securities (see `www.finra.org/industry/trace`). LCPR can be considered a type of "composite" such as BGN but is different from BGN as it accepts *all* contributed pricing without filtering it. LCPR is predominantly based on quotes rather than transactions. See the Bloomberg system for further information on the pricing-source flags. Data sources: Public lists of eligible collateral published on the ECBs webpage, `www.ecb.europa.eu/paym/coll/assets/html/list.en.html`. Daily downloads of pricing sources from Bloomberg.

* Dates refer to when the ECB publishes the lists on its webpage. Lists apply the next business day. This table covers 345 of the in total 360 lists published over this time period. The 15 lists not covered consist of ten lists published from December 19, 2014 to January 1, 2015, and five lists published on November 2, 3, and December 21, 22, and 23, 2015.

		Price Source and Availability								
		Theoretical				**Market**				
	All	Model BVAL	Not found	No Price	Total fraction	Consensus BGN	Indicative EXCH	Transaction TRAC	Quote LCPR	**Avg # of ISINs**
Panel A: All										
All	100.00	50.03	21.13	1.52	72.68	20.65	6.43	0.05	0.18	31,937
Panel B: By liquidity category										
I	6.90	46.61	1.75	-	48.36	48.43	0.56	-	2.65	2,203
II	10.79	47.46	8.75	-	56.21	41.56	2.19	0.04	-	3,441
III	20.66	53.33	15.68	-	69.00	24.98	5.94	0.07	0.00	6,590
IV	58.92	51.59	28.36	-	79.95	11.63	8.36	0.06	-	18,834
V	2.72	11.05	3.48	55.99	70.53	29.47	-	-	-	868
Panel C: By country										
Germany	36.76	76.76	2.18	0.14	79.08	11.90	9.00	0.02	-	11,736
France	19.23	18.45	59.27	0.70	78.42	19.07	2.48	0.04	-	6,147
Spain	6.25	28.92	33.40	5.68	68.00	30.75	1.25	-	-	1,999
Italy	6.89	52.30	2.54	6.79	61.63	29.67	8.70	-	-	2,205
Netherlands	4.99	27.12	20.59	4.79	52.50	42.04	4.81	0.65	-	1,593
United Kingdom	4.88	28.63	25.72	0.38	54.72	34.64	10.60	0.03	-	1,560
Austria	6.03	76.19	5.44	-	81.64	7.84	10.52	-	-	1,925
Belgium	4.77	30.21	56.16	1.08	87.45	11.92	0.63	-	-	1,521
Ireland	1.20	37.52	24.96	6.07	68.54	28.24	3.22	-	-	383
Portugal	0.59	50.86	1.74	9.78	62.38	31.24	6.38	-	-	188
Greece	0.03	31.91	-	-	31.91	68.09	-	-	-	10
Cyprus	0.13	24.77	-	-	24.77	75.23	-	-	-	42
Others	8.25	39.86	12.58	0.89	53.32	38.66	5.70	0.09	2.23	2,628

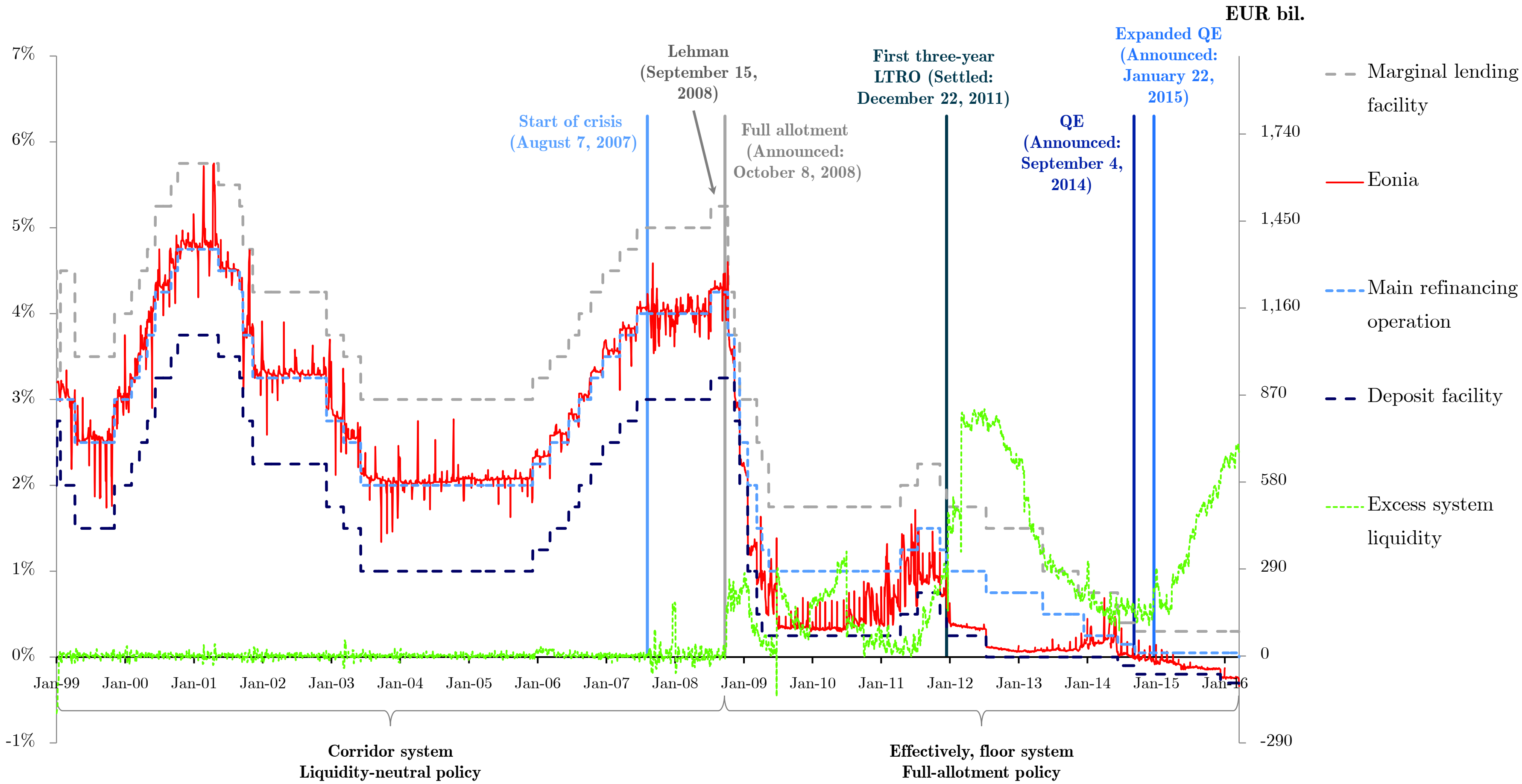
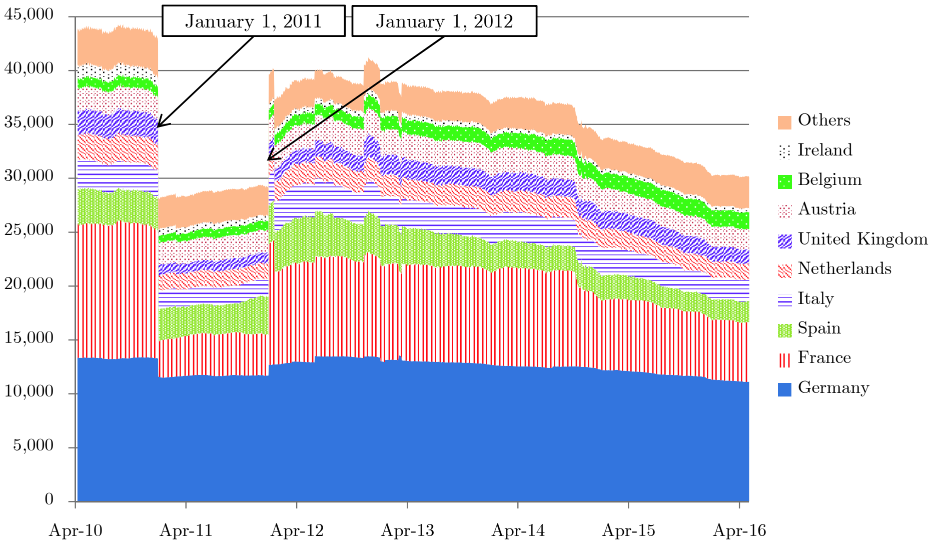


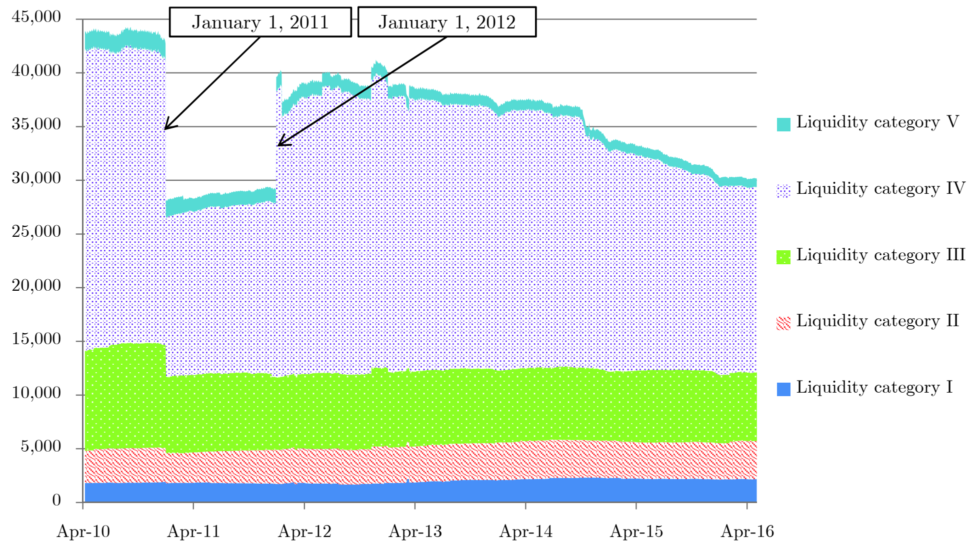
Figure 1: Overnight rates and excess system liquidity

Time period: January 1, 1999, to March 16, 2016.

Eonia is Euro Overnight Index Average. Marginal lending facility, Deposit facility, and Main refinancing operation refer to the (policy) rates in these facilities/operations. Excess system liquidity is aggregate Eurosystem liquidity injections minus banks' aggregate liquidity needs. Liquidity injections are the sum of the daily outstanding MRO and LTRO volumes minus the sterilizing OTs for the Securities Market Programme (SMP). Aggregate liquidity needs are the sum of banks' required reserves (with the Eurosystem) and the net liquidity effect from autonomous factors minus the outstanding amounts from all asset purchase programmes (SMP, CBPP, CBPP1, CBPP2, CBPP3, ABSPP, and PSPP). The figure accounts for the fact that in the three-year LTRO that settled on December 22, 2011, banks had the option to transfer in loans from the one-year LTRO that settled on October 27, 2011. EUR 45,721.45 million out of EUR 56,934.45 million were shifted. So only EUR 11,213 million fell due in the one-year LTRO on November 1, 2012. Reference: press release on December 8, 2011 (`www.ecb.europa.eu/press/pr/date/2011/html/pr111208_1.en.html`). Data sources: `www.emmi-benchmarks.eu/euribor-eonia-org/eonia-rates` (Eonia), `www.ecb.europa.eu/stats/monetary/rates/html/index.en.html` (ECB policy rates), `www.ecb.europa.eu/mopo/implement/omo/html/top_history.en.html` (ECB open market operations), `www.ecb.europa.eu/stats/monetary/res/html/index.en.html` (data on daily liquidity conditions: reserve requirements, net liquidity effect, volume of asset purchase programmes).

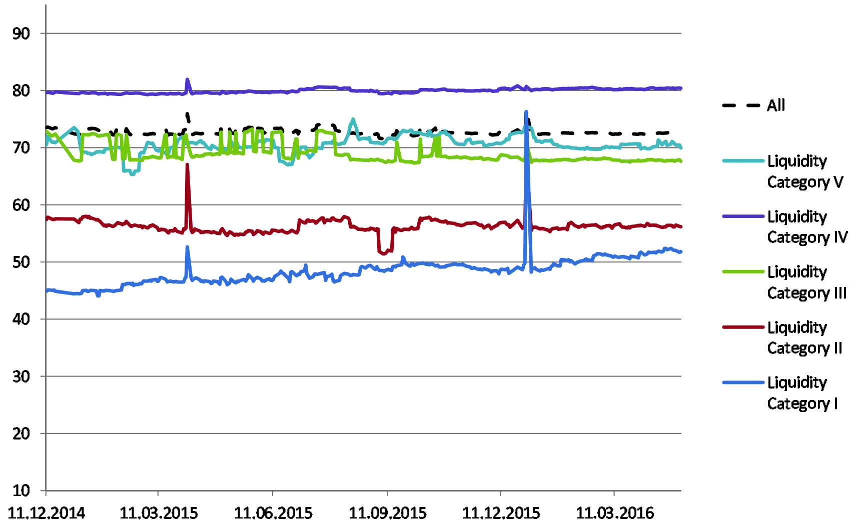


(a) Number of eligible collateral by country of residence of the issuer

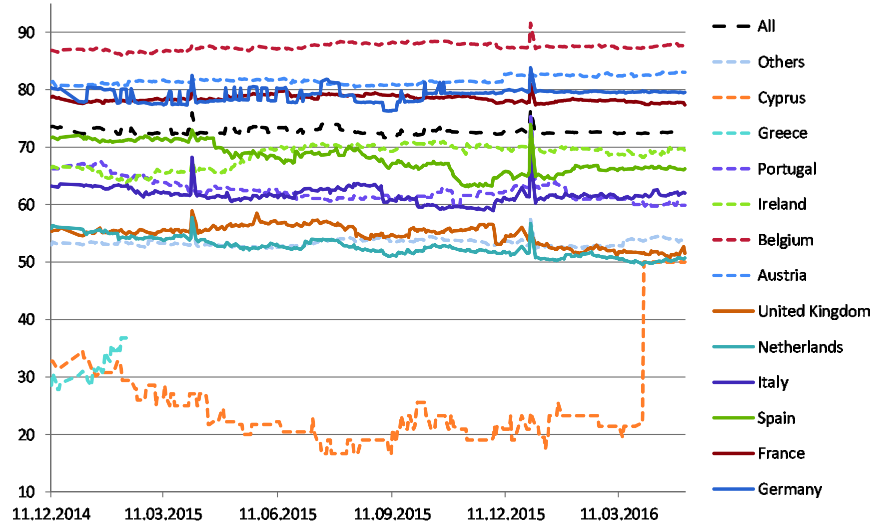


(b) Number of eligible collateral by liquidity category

Figure 2: Number of eligible collateral by country and liquidity category
Time period: April 8, 2010, to May 3, 2016.
These figures show the number of securities in the public list of eligible collateral over time by the country of residence of the issuer (Figure 2a) and liquidity category (Figure 2b). The nine largest (by count) countries are shown individually. The sharp down and up turns at the year-changes 2010/2011 and 2011/2012, respectively, arise because of the exclusion and subsequent re-admission of a large number of unsecured credit institution debt instruments trading on non-regulated markets. Liquidity categories: I. Central government and central bank debt; II. Local and regional government debt, jumbo covered bonds (pfandbrief), agency and supranational debt instruments; III. Traditional pfandbrief and corporate debt; IV. Unsecured credit institution debt instruments, IV. Asset-backed securities.
Data sources: Public lists of eligible collateral, published on the ECB webpage, `www.ecb.europa.eu/paym/coll/assets/html/list.en.html`.



(a) By liquidity category



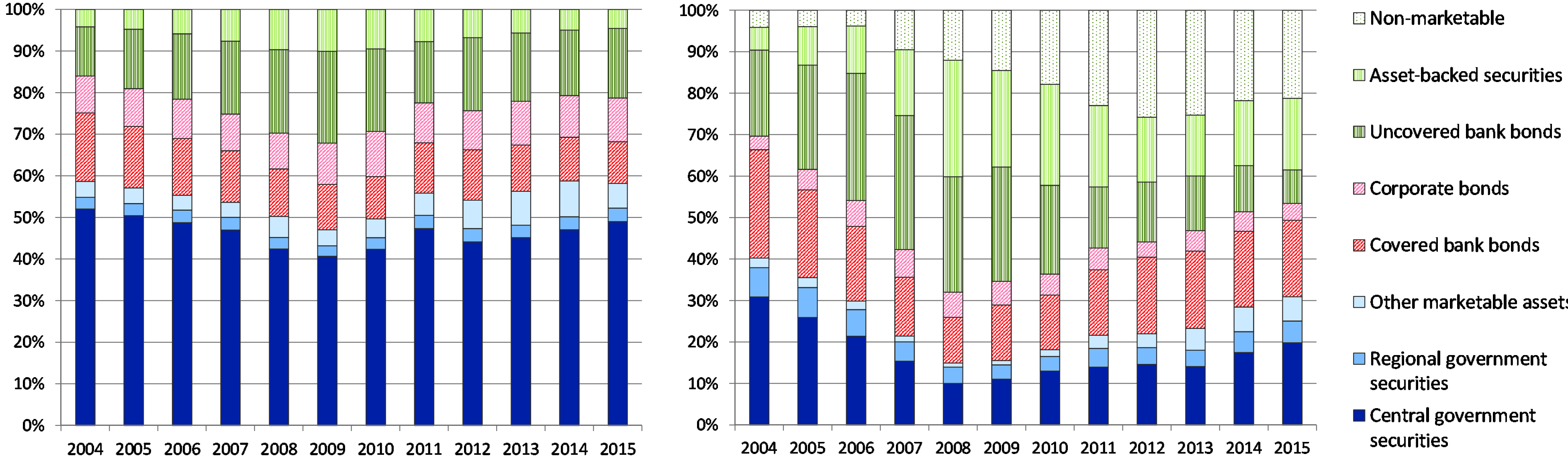
(b) By country

Figure 3: Theoretical prices by liquidity category and country

Time period: December 11, 2014, to May 3, 2016.*

This figure shows time-series of the number of ISINs on the public list of eligible collateral with theoretical prices as a fraction of the total number of ISINs, by liquidity category (Figure 3a) and country (Figure 3b). Note that Greek government-issued or guaranteed collateral lost eligibility as of February 11, 2015. Note also that the number of Cypriot securities dropped to two as of April 1, 2016. Theoretical prices include explicit model prices given by Bloomberg (BVAL), ISINs that cannot be found in Bloomberg, and securities which exist in Bloomberg but for which Bloomberg has no pricing source and price information. See Table 3 for details. Data source: Public lists of eligible collateral, published on the ECB webpage, `http://www.ecb.europa.eu/paym/coll/assets/html/list.en.html` and Bloomberg.

* The dates refer to when the ECB publishes the list of eligible collateral on its webpage. Each file applies the next business day. This table covers 345 of the in total 360 public lists that the ECB published over this time period. The 15 lists not covered by this table are the ten lists around Christmas 2014 (published from December 19, 2014, to January 1, 2015) and the five lists published on November 2 and 3, 2015, and December 21, 22, and 23, 2015.



(a) Composition of eligible marketable collateral

(b) Composition of used collateral

Figure 4: Eligible assets and collateral used
Figure 4a shows the composition of eligible marketable assets across collateral classes based on nominal values. Figure 4b shows the composition of used collateral, including non-marketable assets, based on collateral values. Both sets of figures are based on averages of end-of-month values within each year.
Data source: ECB webpage; `www.ecb.europa.eu/paym/coll/html/index.en.html`; downloaded on May 13, 2016.
* "Other marketable assets" are, according to emails from the ECB, predominantly supranational and agency debt.