Fire Buys of Central Bank Collateral Assets

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Abstract
When central banks act as lender of last resort and provide unlimited liquidity, eligible collateral assets become more valuable than cash and their price increase, the Eligibility Premium. Since securities eligible as collateral are traded over-the-counter, banks more dependent on central bank funding face price discrimination and incur a further premium, the Fire Buy Premium. Moreover, if the risk-shifting channel is open, banks pay an even higher Fire Buy Premium for lower rated collateral assets. With the full fixed-income trading book of 26 German banks, I identify each trade of each bank and investigate how unlimited liquidity provision affects collateral prices. Also, I match banks’ trades with their balance sheet and show how funding liquidity impacts premia payment. I quantify the Eligibility Premium to be 34.7 bps, which demonstrates that unlimited central bank liquidity provision imposes extra costs on banks exactly during stress periods; and the Fire Buy Premium on BBB-rated assets to be 18.4 bps, which prices the severity of the risk-shifting channel in the Eurosystem.

Keywords: Fire Buy Premium, Risk-Shifting Channel, Over-the-Counter Markets

JEL classification: E41, E44, E58, G11, G14, G15, G21

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1 Introduction

In times of financial distress and malfunctioning of the interbank market, central banks often act as lender of last resort and provide banks with unlimited liquidity. In order to access central bank liquidity, banks need to pledge eligible collateral assets. Thus, unlimited central bank liquidity provision may have an impact on the secondary market for these securities. Since the unrestricted provision of liquidity takes place precisely during periods of financial distress, adverse effects on this market may challenge financial stability when it matters most. The scope of the present study is to analyze how changes in central bank liquidity provision affect the secondary market for collateral assets, potentially impacting financial stability.

In 2008, after the Lehman Brothers collapse, many banks lost the access to the European interbank market. In order to provide funding liquidity for those banks and avoid fire sales spirals, the ECB decided to provide unlimited liquidity. In doing so, the ECB changed its usual form of liquidity provision based on variable-rate auctions to fixed-rate full allotment (FRFA) tenders. Using FRFA tenders, banks can draw, at any point in time, as much funding as they desire as long they have enough collateral to pledge. Hence, collateral becomes more valuable than cash because it has similar liquidity properties but yields positive returns. In this study, I show that after the ECB implemented full allotment tenders, eligible collateral assets were traded at a premium, the Eligibility Premium.

Central bank collateral assets are debt instruments, which are traded over-the-counter (OTC). In OTC markets, prices are a result of a bargaining process between counterparties, and price differentiation occurs; see e.g., Duffie, Gârleanu, and Pedersen (2005), Duffie, Gârleanu, and Pedersen (2007), Babus and Hu (2017). Thus, banks dependent on central bank liquidity may have lower bargaining power and face price discrimination when buying collateral asset. In Duffie et al. (2005), an agent’s bargaining power is determined by the outside option to trade, i.e. how quickly an agent can find another counterparty to undertake the trade. Therefore, unlimited central bank liquidity provision reduces banks’ bargaining power in two ways. First, banks may want to execute the trade more quickly so they can pledge the asset as collateral. Second, banks needing central bank liquidity tend to hold on to their collateral assets, reducing the matching probability between buyers and sellers. I name the Fire Buy Premium, the price premium banks, more reliant on ECB funds, pay to acquire collateral assets.

In order to mitigate scarcity of collateral assets, the ECB enlarged its collateral framework to accept BBB-rated assets. However, the haircut the ECB applied to these newly eligible assets did not reflect their risk, i.e. these securities enjoyed a haircut subsidy. Since banks can exploit this subsidy from the ECB, they are willing to incur an even higher Fire Buy Premium for BBB-rated assets, which prices the risk-shifting channel in the Euro area.

1 In 2010, the ECB reviewed its haircut policy and concluded that all haircuts applied to BBB-rated assets should be revised upwards. This revision was implemented on 1st January 2011. See Appendix and ECB press release “ECB introduces graduated valuation haircuts for lower-rated assets in its collateral framework as of 1 January 2011” from April 4th 2010.

2 BBB-rated assets are investment grade and, by definition, good quality collateral. Thus, this study does not address the riskiness level of these assets but rather the haircut applied to them.
The objective of this paper is to present evidence for the existence of both premia and quantify them. To this end, I match the fixed-income trading book of 26 German banks with their funding liquidity in ECB open market operations. My results show that after the introduction of FRFA tenders banks pay a Eligibility Premium of 34.7 basis points and banks are more likely to buy then sell collateral assets. Also, banks more reliant on ECB funds pay on average 27.2 bps, 8.4 bps, 6.3 bps, and 18.5 bps to acquire AAA-, AA-, A-, and BBB-rated collateral assets, respectively, the Fire Buy Premium.\(^3\)

The novel part of my study is to link changes in the central bank collateral framework with prices of fixed-income instruments. My contribution is twofold. First, the existence of the Eligibility Premium demonstrates that the implementation of unlimited central bank liquidity provision imposes an extra cost on banks when they need liquidity most. Second, the Fire Buy Premium evidences that monetary policy affects banks bargaining power and banks more dependent on the central bank also pay more to acquire collateral assets. Moreover, the noticeable high Fire Buy Premium for BBB-rated assets suggests that the risk-shifting mechanism is open in the Eurosystem and it provides a price effect for the risk-shifting channel. As result, it underscores the fact that haircut subsidy as a form of financial support for banks is not an efficient policy because the subsidy is passed on to other banks in form of premium payment.

My identification strategy offers a rare opportunity to match banks’ trading behavior (at the bank-security level) with banks’ funding liquidity. I use several valuable data sets. First, I have the full fixed income trading book of 26 German banks. With this data set I can identify for each transaction the security being traded, the buyer, the seller, the size and the price of the trade (among other variables). Second, I am able to look into banks’ balance sheet and recognize how much liabilities they have to the Eurosystem. In this way, I am able to identify how dependent a bank is on central bank funding and link this to its respective trading behavior. Third, I have the list of eligible collateral assets at the ECB as published on its website and the rating applied by the ECB to each security.\(^4\) Thus, I can unambiguously identify how a bank’s trading behavior changes with the FRFA announcement and conditional on its central bank funding liquidity.

The identification strategy of the Fire Buy Premium is based on the cross sectional difference of banks. The Fire Buy Premium is derived from banks’ loss of bargaining power, which results in worse economic outcomes, i.e. buying at a premium and selling at a discount. These effects would mutually cancel out if they were to be jointly estimated. Therefore, my identification strategy of the Fire Buy Premium consists in estimating buy and sell orders separately (Section 5 and Section 8.2, respectively).

The identification strategy of the Eligibility Premium is based on the cross sectional difference of securities. To identify the extra value a security has because it is eligible as collateral at the ECB, I compare the price of eligible and ineligible securities. However, most ineligible securities are not accepted as collateral because they do not fulfill the ECB’s requirement and for this reason they are not a perfect control group. In order to

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\(^3\)By way of comparison, the 10 years German Bund, the safest assets in the ECB collateral pool, yielded on average \(\sim 400\) bps in 2008. In October 2008, the BBB-spread averaged \(\sim 600\) bps (measured by the Bank of America US Corporate BBB Option-Adjusted Spread).

\(^4\)For a given security the binding rating for the ECB is the best one among the accepted agencies. In 2008, the ECB accepted only ratings from the big three agencies: Standard & Poor’s, Moody’s and Fitch. In 2009, the ECB started accepting ratings from DBRS.
construct a comparable control group, I use assets that comply with the ECB eligibility rules but are still not included at the ECB Collateral Framework. Although there is a restricted number of securities that fulfill this criteria, they show a similar trend to eligible assets prior to the treatment.

The sample of banks includes 26 large German banks. Although this group is relatively small compared to the large number of European banks with access to the ECB open market operations, the group is sufficiently heterogeneous. In my sample, 10 banks received liquidity injection from the government (state and/or central government). Moreover, there are three banks in my sample that no longer exist. This mixture of relatively healthy banks with others more distressed resembles the broader European banking landscape.

In OTC markets, non-dealer participants normally pay a premium to trade with dealers; see e.g. Li and Schürhoff (2014) and Di Maggio, Kermani, and Song (2017). Thus, a potential criticism of my findings is that the premia described in this study may be driven by the OTC market structure. In order to disentangle the Eligibility and Fire Buy premia from the premium paid to trade with a dealer, I identify the trades in the sample, which have dealers as counterparty and test if my findings are robust to the dealer-non-dealer structure of OTC markets. I find no evidence that the network structure of OTC markets drive my results. Furthermore, I perform other falsification tests. My results are robust to anticipation effects, to interaction with Lehman Brothers bankruptcy, and to different definition of my main explanatory variable, dependence on ECB funding.

This paper links the literature on over-the-counter financial markets with the literature on unlimited central bank liquidity provision. Bagehot (1873) proposes that, in times of financial distress, monetary authorities should lend in an early and unlimited manner to solvent banks, against appropriate collateral at high interest rates. Rochet and Vives (2004) provide a formal model for Bagehot’s doctrine, in which even in modern interbank markets, central bank’s liquidity intervention is desired.

However, how the implementation of lender of last resort policies should be designed is an open debate. On the one side, Koulischer and Struyven (2014) and Choi, Santos, and Yorulmazer (2016) show using theoretical arguments that when the central bank acts as lender of last resort, availability of collateral assets become an issue and an enlargement of the collateral framework is necessary. In Choi et al. (2016), an enlargement of the collateral framework is necessary because unlimited central bank liquidity provision withdraws good collateral from the market and exposes banks in the possession of lower rated collateral assets to liquidity risk. On the other side, Drechsler, Drechsel, Marques-Ibanez, and Schnabl (2016) and Fecht, Nyborg, Rocholl, and Woschitz (2016) show that unlimited central bank liquidity provision may open the risk-shifting channel. They argue empirically that whenever a haircut does not cover collateral risk, liquidity provision is undercollateralized and the monetary authority bears part of the risk. Both studies present evidence that the risk-shifting channel is specially prone for lower rated collateral assets, or the newly eligible ones.

My study adds to the debate by providing a price effect for both argumentation lines. The Eligibility Premium evidences that indeed the scarcity of collateral assets is an issue and an expansion of the collateral framework is necessary as in Choi et al. (2016). The notorious high Fire Buy Premium for BBB-rated collateral assets shows that the risk-shifting channel is not closed for these securities. According to my results, the Eligibility
Premium is larger than the Fire Buy Premium, and the Eligibility Premium affects a larger set of assets, suggesting that in the short run the availability of collateral assets is a greater concern for monetary authorities.

2 Theoretical Background

2.1 Eligibility Premium

Eligibility Premium is the price premium of an asset attributable to the fact that it is eligible as collateral at the central bank. This premium is especially high, during crisis periods, when the central bank provides unlimited liquidity. In this case, collateral assets become more valuable than cash because they have positive returns and can be exchanged for cash at any time. Thus, during financial crisis when banks hoard liquidity, as in Heider, Hoerova, and Holthausen (2015) and Diamond and Rajan (2011), it is preferable to hoard collateral assets.

The Eligibility Premium evidences that the lender of last resort policy imposes an extra cost to banks through the increased price of collateral. The reason why central banks provide unlimited liquidity is to provide funding liquidity to banks in times of financial distress. The counterfactual of this policy is that some banks would have no other way to refinance, potentially starting fire sale spirals. In trying to avoid fire sales, the monetary authority prompts fire buys of collateral assets, which represents one cost related to the provision of unlimited central bank liquidity. However, the Eligibility Premium cannot be interpreted as an argument against full allotment tenders because its welfare lost is probably smaller than the costs of no action.

In fact, the Eligibility Premium is an argument in favor of the expansion of the collateral framework when the provision of liquidity is unlimited, as indeed the ECB provided.

2.2 The Fire Buy Premium

The Fire Buy Premium is the premium that banks in great need of central bank liquidity pay to acquire collateral assets. It arises because collateral assets are traded OTC, where prices are opaque and discrimination occurs. Duffie et al. (2005) and Duffie et al. (2007) demonstrate that prices in OTC markets are not unique but rather a result of a bargaining process, where the bargaining power is the outside option to trade and participants with less bargaining power face price discrimination. The outside option to trade is given by how quickly an agent can find another counterparty to execute the trade. In the present context, unlimited central bank liquidity provision reduces bargaining power in two ways. First, it imposes timing pressure on the execution of the trade so that banks can use the asset as collateral. Second, it induces banks to hold more collateral assets, which reduces the number of sellers, increases the number of buyers, and affects the matching

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5Bindseil and Papadia (2006) presents some anecdotal evidence that in normal times the Eligibility Premium is close to zero in the Euro area.
6Even when the collateral asset is pledged at the central bank, the returns of the asset go to the borrowing bank.
7A welfare analysis between the costs and the gains from unlimited central bank liquidity provision goes beyond the scope of this study.
probability in OTC markets. Thus, Fire Buy Premium is the price discrimination derived from lender of last resort policy.

The Fire Buy Premium also relates to the risk-shifting channel because the premium is especially high for lower rated collateral assets. The risk-shifting theory says that some banks may use central bank liquidity lines to shift risks from their balance sheet to the monetary authority. This channel is open when the haircut applied by the central bank is below the market. In this case, transactions are undercollateralized, and the central bank bears part of the loss should issuer and counterparty default. In the Eurosystem, this haircut subsidy is higher for lower-rated collateral securities (Drechsler et al. (2016)). Because the haircut subsidy is higher for BBB-rated assets banks incur stronger Fire Buy Premium when purchasing them.

The reason why the risk-shifting channel benefits banks differently is that in private repos they receive haircuts based on the collateral risk and on the correlation risk between collateral and their own counterparty risk, whereas in the ECB funds market haircuts adjust only to security risk. For instance, an Austrian and a Portuguese bank of similar rating might receive different haircuts in private repos when using a Portuguese sovereign bond as collateral. This differentiation happens because, in the scenario where Portugal is bankrupt, Portuguese banks are also likely to be bankrupt, whereas an Austrian bank would be less affected. This correlation risk is not taken into account in the Eurosystem (see Fecht et al. (2016) for further discussion).\(^8\)

The existence of the Fire Buy Premium has three implications. First, banks more reliant on ECB funds face price discrimination. Second, with the presence of haircut subsidies the provision of central bank liquidity is also a financial support. If this subsidy was provided intentionally to support banks during the financial crisis, it was not an efficient policy because the financial support was passed on to other banks in the form of premia payments. Third, if banks are willing to incur an extra Fire Buy Premium for BBB-rated assets, it is because they can exploit the risk-shifting channel by at least this amount. Thus, the Fire Buy Premium prices how much a bank values the risk-shifting channel and serves as indicator of how severe the risk-shifting channel is.

3 Data

3.1 Data Sources

The innovation of this study is to use a novel data set that allows me to identify trading behavior in the security-bank dimension and match it with respective bank balance sheets. To this end, I merge several data sets. First, banks’ fixed income trades provided by the German Federal Financial Supervisory Authority (BaFin). Second, the daily list of assets

\(^8\)The ECB explains: “In contrast to commercial banking practice, where haircuts can be set at more stringent levels for counterparties with higher perceived credit risk, the Eurosystem, in line with its mandate to maintain a level playing field among market participants, cannot apply differentiated haircuts in its policy operations, i.e. haircuts that would depend on the creditworthiness of the counterparty. Furthermore, the Eurosystem calculates the haircut on an asset-by-asset basis, not adjusting the haircuts to the diversification or concentration features of the collateral pool. Additionally, the Eurosystem retains the ability to apply additional discretionary haircuts on an asset.” Source: The Financial Risk Management of the Eurosystem’s Monetary Policy Operations, ECB website.
eligible as collateral at the ECB, along with their respective ratings, made available by the Deutsche Bundesbank. Third, banks’ balance sheet statistics, also furnished by the Deutsche Bundesbank.

Section 9 of the German Securities Trading Act states that all credit and financial services institutions must report to the German Federal Financial Supervisory Authority (BaFin) any transaction in securities or derivatives which are admitted to trading on a regulated market (including over-the-counter trades). From this data source, I obtained all fixed income transactions undertaken by 26 German banks between January 1st and December 31st 2008 including the buyer, seller, security, time, price and quantity.\(^9\) The definition of fixed-income includes all debt instruments defined by Bloomberg. Each trade is reported only once and can be a positive (buy order) or a negative value (sell order). The raw dataset reports a total of 5,137,652 trades (2,530,426 buy orders and 2,607,226 sell orders). In order to prevent small trades from driving my results, I exclude all trades with a volume smaller than €100,000.00 or the equivalent thereof and 2,997,707 observations are left. The data set distinguishes between proprietary and client trade. I focus only on own-account trades, which leaves 2,973,026 observations. In order to treat trades on a daily basis I average prices weighted by their order size. After this transformation the data set contains 787,079 observations.

Every day the ECB publishes a list of all assets eligible as collateral, also called the Single List.\(^10\) This document is a list containing all securities (security-by-security) accepted by the ECB including information on each respective coupon, haircut, issuance date, maturity date, among other characteristics. By comparing the changes in the assets in the list, I am able to identify which assets have been added to and removed from the ECB collateral framework. Moreover, I received a list, courtesy of the Bundesbank, broken down by the asset rating applied by the ECB.\(^11\) From this data set, I am able to identify the securities in banks’ trading books that belong to the ECB Collateral Framework, and categorize them by ratings and haircut. To avoid issues caused by the issuance and maturity of assets during the observation period, I focus only on eligible assets that were in the list at the beginning and at the end of the year (except for BBB-rated assets that were only added in October).

The Balance Sheet Statistics of the Deutsche Bundesbank (BISTA) provide a monthly bank-by-bank overview of banks’ activities. Among other variables, it contains the size of banks (total assets) and the total central bank funds in their balance sheet. With this information, I create the main explanatory variable, central bank funding over total assets, among other variables. All variables are provided monthly and linearly interpolated into weekly data.

### 3.2 Descriptive Statistics

Table 1 describes bank specific characteristics of the 26 banks in the sample with a monthly frequency from January to December 2008. The first covariate is banks’ reliance on ECB

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\(^9\)The time period and bank sample are chosen according to data availability.

\(^10\)The Single List is a list published every day on the ECB’s website.

\(^11\)For a given security the binding rating for the ECB is the best one among the accepted agencies. In 2008, the ECB accepted only ratings from the big three agencies: Standard & Poor’s, Moody’s and Fitch. In 2009, the ECB started accepting ratings from DBRS.
funding as a share of their size, the variable of our primary interest. To understand
how characteristics of banks reliant on ECB funds differ from other banks, I present the
variables divided in two groups. The first group I name \textit{Non ECB Dependent} and define
as the observations in each period correspondent to 50 percentile least dependent on ECB
funds. The other group is named \textit{ECB Dependent} the 50 percentile of more ECB reliant
banks.

Table 1: Distribution of Bank Variables by Bank Groups. \textit{ECB Dependent} is
defined as the 50th percentile of banks more dependent ECB funds in a given month; \textit{Non
ECB Dependent} are the all other banks. Monthly data from January 2008 to December
2008. \textit{ECB Funding} is banks’ liabilities to the ECB over total assets, \textit{Equity Ratio} is
equity over total assets, \textit{Interbank Liabilities} are liabilities to other monetary financial
institutions over total assets, \textit{Net Position Interbank} are claims minus liabilities to other
monetary financial institutions over total assets, \textit{Cash} is cash and central bank money as
share of total assets, \textit{Security Portfolio} is the holding of stocks and fixed-income instru-
ments over total assets (this figure does not include assets pledged in repo transactions).

<table>
<thead>
<tr>
<th>\textbf{Non ECB Dependent}</th>
<th>Mean</th>
<th>Std Error</th>
<th>10th pcl</th>
<th>25th pcl</th>
<th>50th pcl</th>
<th>75th pcl</th>
<th>90th pcl</th>
<th># Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECB Funding (%)</td>
<td>1.6</td>
<td>1.2</td>
<td>0.0</td>
<td>0.2</td>
<td>1.6</td>
<td>2.7</td>
<td>3.2</td>
<td>154</td>
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<tr>
<td>Net Position Interbank (%)</td>
<td>0.8</td>
<td>8.0</td>
<td>-8.8</td>
<td>-5.0</td>
<td>2.5</td>
<td>5.7</td>
<td>8.7</td>
<td>154</td>
</tr>
<tr>
<td>Interbank Liabilities (%)</td>
<td>26.9</td>
<td>12.4</td>
<td>9.5</td>
<td>13.3</td>
<td>28.3</td>
<td>35.1</td>
<td>46.1</td>
<td>154</td>
</tr>
<tr>
<td>Total Assets (billion €)</td>
<td>16.8</td>
<td>12.3</td>
<td>3.3</td>
<td>5.2</td>
<td>14.1</td>
<td>27.1</td>
<td>37.5</td>
<td>154</td>
</tr>
<tr>
<td>Equity Ratio (%)</td>
<td>3.1</td>
<td>1.3</td>
<td>1.4</td>
<td>2.1</td>
<td>3.1</td>
<td>3.9</td>
<td>5.0</td>
<td>154</td>
</tr>
<tr>
<td>Cash (%)</td>
<td>0.6</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.7</td>
<td>1.3</td>
<td>154</td>
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<tr>
<td>Security Portfolio (%)</td>
<td>20.7</td>
<td>10.7</td>
<td>5.2</td>
<td>14.5</td>
<td>19.5</td>
<td>26.7</td>
<td>40.2</td>
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<th>\textbf{ECB Dependent}</th>
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<td>4.5</td>
<td>3.5</td>
<td>4.3</td>
<td>6.4</td>
<td>9.9</td>
<td>13.7</td>
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<td>3.3</td>
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<td>Equity Ratio (%)</td>
<td>2.9</td>
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<td>2.7</td>
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<tr>
<td>Cash (%)</td>
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<td>0.4</td>
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<td>0.1</td>
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In Non ECB Dependent group, the ECB provides on average 1.6% the banks’ liabilities.
This figure increases to 7.8% in the ECB Dependent group. To illustrate how important
ECB funding is for banks during the period, I present banks’ net position in the interbank
market defined as interbank lending minus interbank borrowing divided by total assets.
If this variable is positive banks lend more to other banks than they borrow, if negative
they borrow more. The net in the interbank market of Non ECB dependent observations is 0.8%, suggesting that they provide more funds to the banking sector than they draw. ECB Dependent, on the other hand, have a net position in the interbank market of -3.5%, suggesting that on average they draw more liquidity from the banking sector than they provide. To complete the picture, I present interbank liabilities as share of balance sheet size. On average, 26.9% of the Non ECB Dependent group liabilities are from the interbank market, and in the ECB Dependent group this figure rises to 33.9%.

Other bank variables do not differ so substantially. On average, total assets of the Non ECB Dependent group is 16.8 billion €, and ECB Dependent group 14 billion €. Equity ratio is the amount of bank equity over total assets and averages 3.1% in the Non ECB Dependent group and 2.9 in the ECB Dependent group. Cash is defined as holdings of central bank money over total asset and amounts 0.6% in the first and 0.4% in the second group. Security Portfolio is the share of securities (equities and fixed income) holdings to total assets. Its size is 20.7% in Non ECB Dependent group and 27.7% in the ECB Dependent group.

Table 2 describes further control variables. Weekend and holiday values are interpolated so they can be matched with trade on those days. S&P 500 is a U.S. stock index and is used as a proxy for the general condition of capital markets. VIX is the implied volatility of the S&P 500 and used as a measure of market wide risk aversion. The average value, 32.64, represents the expected range of movement in the S&P 500 index over the next year. To represent the yield curve I use the one month, three months, and the one year Euribor. Their respective average values are 4.27, 4.63, and 4.81, which suggests an upward sloping yield curve. For a given asset, market liquidity is measured by the total number of trades in the last 5 trading days (in sample) and its average value is 15.59. Order size represents the size of the trade and is defined in number of securities. The average order size is 5,245,298. This figure is much higher than the median, 41,800, suggesting very large outliers.

Table 2: Distribution of security control variables. S&P 500 is a U.S. stock index, VIX is the CBOE volatility index, Euribor 1M, 3M, and 1Y are the one month, three months, and one year reference rates for the European interbank market, Liquidity is the cumulative number of trades in the previous 5 trading days (in sample) for a given asset, Order Size is the size of the trade order in number of securities. Weekend and holiday values are linearly interpolated. Source: Bloomberg and BaFin

<table>
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<th>10th pc</th>
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<td>1220</td>
<td>190</td>
<td>877</td>
<td>1141</td>
<td>1286</td>
<td>1360</td>
<td>1396</td>
<td>365</td>
</tr>
<tr>
<td>VIX</td>
<td>32.64</td>
<td>16.29</td>
<td>19.60</td>
<td>21.98</td>
<td>25.10</td>
<td>41.63</td>
<td>59.98</td>
<td>365</td>
</tr>
<tr>
<td>Euribor 1M</td>
<td>4.27</td>
<td>0.48</td>
<td>3.52</td>
<td>4.19</td>
<td>4.37</td>
<td>4.48</td>
<td>4.59</td>
<td>365</td>
</tr>
<tr>
<td>Euribor 3M</td>
<td>4.63</td>
<td>0.51</td>
<td>3.97</td>
<td>4.38</td>
<td>4.85</td>
<td>4.96</td>
<td>4.96</td>
<td>365</td>
</tr>
<tr>
<td>Euribor 1Y</td>
<td>4.81</td>
<td>0.59</td>
<td>4.07</td>
<td>4.39</td>
<td>4.95</td>
<td>5.34</td>
<td>5.42</td>
<td>365</td>
</tr>
<tr>
<td>Liquidity</td>
<td>15.95</td>
<td>52.66</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>13</td>
<td>36</td>
<td>787,079</td>
</tr>
<tr>
<td>Order Size</td>
<td>5,254,298</td>
<td>2.64 × 10^8</td>
<td>2,000</td>
<td>7,500</td>
<td>41,800</td>
<td>310,000</td>
<td>4,000,000</td>
<td>787,079</td>
</tr>
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</table>
Table 3: **Mean and standard errors of securities characteristics by rating and ECB categories.** Monthly number of trades, mean over months. Maturity of perpetual bonds treated as 100 years. Category I: central government debt instruments, debt instruments issued by central banks; Category II: local and regional government debt instruments, Jumbo Pfandbrief, agency and supranational debt instruments; Category III: covered bonds, traditional Pfandbrief, credit institution debt instruments, debt instruments issued by corporates; Category IV: asset-backed securities. Note: with the expansion of the collateral framework, the ECB created a further category (uncovered debt) which is excluded from the analysis since I do not observe any trade with these assets. Missing prices omitted for confidentiality reasons. Source: BaFin and ECB.

<table>
<thead>
<tr>
<th></th>
<th>Category I</th>
<th>Category II</th>
<th>Category III</th>
<th>Category IV</th>
<th>Ineligible</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AAA</td>
<td>AA</td>
<td>A</td>
<td>BBB</td>
<td>AAA</td>
</tr>
<tr>
<td>Price</td>
<td>100.67</td>
<td>99.72</td>
<td>98.3</td>
<td>101.30</td>
<td>96.57</td>
</tr>
<tr>
<td></td>
<td>(4.54)</td>
<td>(3.29)</td>
<td>(4.82)</td>
<td>(3.30)</td>
<td>(3.95)</td>
</tr>
<tr>
<td>Mean Coupon (%)</td>
<td>4.00</td>
<td>4.12</td>
<td>4.51</td>
<td>3.67</td>
<td>3.09</td>
</tr>
<tr>
<td></td>
<td>(0.83)</td>
<td>(0.96)</td>
<td>(1.00)</td>
<td>(0.82)</td>
<td>(0.97)</td>
</tr>
<tr>
<td>Mean Haircut (%)</td>
<td>3.22</td>
<td>1.63</td>
<td>2.96</td>
<td>9.77</td>
<td>3.94</td>
</tr>
<tr>
<td></td>
<td>(1.35)</td>
<td>(2.39)</td>
<td>(2.30)</td>
<td>(209)</td>
<td>(1.51)</td>
</tr>
<tr>
<td>Mean Days-to-Maturity</td>
<td>2,470</td>
<td>1,985</td>
<td>1,693</td>
<td>1,935</td>
<td>1,126</td>
</tr>
<tr>
<td></td>
<td>(2,409)</td>
<td>(2,396)</td>
<td>(3,302)</td>
<td>(209)</td>
<td>(894)</td>
</tr>
<tr>
<td>Monthly # Trades</td>
<td>13,064</td>
<td>3,335</td>
<td>767</td>
<td>40</td>
<td>12,521</td>
</tr>
<tr>
<td></td>
<td>(4,199)</td>
<td>(4,141)</td>
<td>(276)</td>
<td>(35)</td>
<td>(3,731)</td>
</tr>
<tr>
<td>Monthly Turnover (in € billion)</td>
<td>7,060</td>
<td>1,520</td>
<td>224</td>
<td>1.7</td>
<td>2,080</td>
</tr>
<tr>
<td></td>
<td>(3,583)</td>
<td>(3,301)</td>
<td>(171)</td>
<td>(2)</td>
<td>(1,028)</td>
</tr>
<tr>
<td># Assets</td>
<td>272</td>
<td>146</td>
<td>40</td>
<td>7</td>
<td>599</td>
</tr>
<tr>
<td></td>
<td>(9)</td>
<td>(6)</td>
<td>(4)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
</tbody>
</table>
Table 3 presents the mean and standard errors of securities characteristics.\footnote{I aggregate assets rated AA+, AA, and AA- into AA and similarly for rate buckets A, and BBB.} Assets are divided into four categories according to Table 10 in the Appendix: (I) central government debt instruments and debt securities issued by central banks; (II) local and regional government debt instruments, Jumbo Pfandbrief, agency and supranational debt instruments; (III) covered bonds, traditional Pfandbrief, credit institution debt instruments, debt instruments issued by corporates; (IV) asset-backed securities (ABSs). In general terms, prices tend to be around 100 and with a standard deviation of around 3. This feature is common in fixed-income assets, where a par value is paid at maturity. The average haircut ranges mostly between 3% and 4% for assets rated AAA, AA, and A; and 7% to 10% for BBB assets. Although theoretically haircuts could go up to 20%, the mean is far lower. Lastly, assets of type (III) are the most populated.

4 The Eligibility Premium

4.1 Empirical Strategy

In this section, I investigate the cross section of assets to understand whether the introduction of fixed-rate full allotment tenders impacts the price of fixed-income securities. My estimation strategy is a differences-in-differences model (before/after FRFA, eligible/ineligible as collateral assets), where the interaction term, $\alpha_1$, indicates how much more expensive eligible assets became after the introduction of FRFA compared to ineligible assets, the Eligibility Premium.

$$p_{ibt} = \alpha_1 FRFA_t \times eligible_i + \alpha_2 FRFA_t + \Gamma X_{it} + \theta p_{i(t-1)} + \Delta_i + \Delta_{bw} + u_{ibt} \quad (1)$$

where $p_{ibt}$ is the price bank $b$ pays for security $i$ at day $t$,\footnote{I use prices instead of yields because the majority of the trades are widespread.} $FRFA_t$ is a dummy variable that takes the value of 1 after the ECB announces fixed-rate full allotment tenders on October 8th 2008,\footnote{In Equations (1) and (2) \textit{FRFA}_t is not suppressed because the fixed-effects are defined weekly whereas \textit{FRFA}_t daily.} $eligible_i$ is a dummy that takes the value of 1 if the ECB accepts security $i$ as collateral and zero otherwise,\footnote{Although the eligibility status changes for BBB-rated assets change during my sample period, the number of observations is not large enough to significantly differ from security fixed effects.} $X_{it}$ is a vector of security control variables, $\Delta_i$ and $\Delta_{bw}$ are security, and bank-week fixed effects, respectively, and $u_{ibt}$ is the error term. Further, in order to avoid autocorrelation I include the AR(1) process. The lagged price variable, $p_{i(t-1)}$, is a constructed variable based on the interpolation of prices within the sample and does not necessarily mean that the asset was traded at this price on the previous day. In order to match weekly with daily variables, I repeat the week value in all days of the week. I opted for this method because balance sheet statistics are reported on a monthly basis and interpolated into weekly data. Interpolating the data further into daily statistics would add no economic meaning. As it is common use in differences-in-differences approach, I restrict the sample period to have same length in terms of days before and after the treatment.

The use of time-varying bank fixed-effects accounts for all variation in the bank-week...
dimension and dismisses the use of bank control variables. On the security dimension, I use security fixed-effects and control variables to account for time-varying effects. In an alternative specification, I use time-varying fixed effects in the security and in the bank dimensions. This is a very restrictive approach that only identifies the Eligibility Premium within the week of the policy implementation but serves to illustrate the robustness of the results.

The main concern in estimating Equation (1) is the comparability of control and treatment groups. In principle, all euro denominated fixed-income securities that fulfill the eligibility criteria should be part of the control group, which would rule out the possibility of an equivalent treatment group. However, the ECB reserves its right to use ad-hoc decisions to exclude assets from the eligibility list. I use these ad-hocs decisions of the ECB to construct a comparable treatment group. In banks’ fixed-income trading book, I identified 82,196 euro denominated ineligible bonds. Out of this group, I identify 342 bonds that are investment grade according to Standard & Poors. Conforming to the ECB guidelines (see Appendix), if at least one of the big three rating agencies rate a bond investment grade it should be considered eligible as collateral at the ECB. Nevertheless, these assets are not included in the Single List.

In order to show that my control and treatment groups follow a common trend before the treatment, I present Figure 1. It shows that prices followed a similar pattern until late 2008, when Lehman Brothers went bankrupt and the ECB played the role of lender of last resort. In the later period of the sample, the price of ineligible assets declined whereas price of eligible ones remained around similar levels. From mid October until end of the year both price lines have an upward trend. My empirical strategy is to show that this trend is steeper for eligible assets. Eligible collateral assets are more valuable when the ECB provides unlimited liquidity because they can be exchanged at any point in time for central bank money and yield positive returns.

![Figure 1: Security Prices.](image_url)

Figure 1: **Security Prices.** Eligible: black line. Ineligible: dashed line. Weekly average price of securities aggregated by eligibility status. Sources: own calculation.

To complete the picture, I investigate if unlimited central bank liquidity provision also affects banks’ propensity to buy eligible assets. For this end, I estimate a linear probability
model (OLS) using a differences-in-differences approach. The left hand variable, $\rho_{ibt}$, equals 1 if bank $b$ buys security $i$ at day $t$, -1 if it sells and zero otherwise. As before the treatment group are Euro denominated ineligible investment grade bonds.

$$\rho_{ibt} = \beta_1 FRFA_t \times \text{eligible}_i + \beta_2 FRFA_t + \Pi X_{it} + \Delta_i + \Delta_{bw} + e_{ibt} \quad (2)$$

For the estimation of Equation (2), I expand the data sample with zeros for all combinations of bank-security-time, where no trade takes place.

Equation (2) is not a typical probability model because agents have multiple choice and values range from -1 to 1. In this context, if $\hat{\beta}_1 = -1$ banks sell security $i$ with certainty. Conversely, if $\hat{\beta}_1 = 1$ banks buy security $i$ with certainty. Thus, the estimated coefficient indicates the propensity that agents take one action instead of other.

4.2 Results

In Table 4, Regressions (I) and (IV) present the estimations of Equations (1) and (2) with standard errors clustered on the bank-security dimension. Regressions (II) and (V) are similar but instead of using security control variables, they use security-week fixed effects. Regression (III) is similar to (II) but the treatment date is implementation of the first fixed-rate full allotment tender on the 15th October 2008.

Regression (I) shows that after the introduction of FRFA banks pay a Eligibility Premium of 34.7 bps. The result is significant at the 1% level and is in line with my conjecture; banks pay a Eligibility Premium to buy ECB collateral assets after the announcement of FRFA tenders.

In regression (II), the use of security-week fixed effects comes at a cost. Demeaning prices in the security-week dimension extracts all possible price impact of FRFA that goes beyond the week of the treatment. Therefore, the effect captured by this coefficient is identified only within the week of the policy announcement and can be seen as the short-term impact of FRFA. The main result holds, banks pay a premium to buy eligible collateral assets after the introduction of unlimited liquidity provision. The magnitude of the coefficient is much higher, 1.6, and suggests that, in the short term, the ECB action was received with euphoric mood by the markets.

Regression (III) presents the results for Equation (1) using the first actual tender as treatment. The main result remain unchanged. Eligible collateral assets become 23 bps more expensive after the implementation of FRFA tenders.

The coefficients of other variables illustrate market conditions at the time. The significance of $FRFA_t$ in all specifications shows a negative price trend across all assets in the sample in the week of the introduction of FRFA. This effect relates to the financial crisis of 2008, where a negative price trend across assets is common. Large orders, Order Size$_{ibt}$, have larger price impact. Assets traded more often, liquidity$_{ibt}$, relate to lower prices. An increase in S&P 500 relates to higher prices. Higher market volatility, $VIX_t$, relates to lower prices. Higher short-term interest rates, $euribor3M_t$, relates to higher prices; and higher medium term interest rates, $euribor1Y_t$, relates to lower prices.

Turning to the propensity that banks buy collateral assets, regression (IV) presents a similar picture. After FRFA, banks tend to buy more eligible collateral assets. The coefficient of the interaction term, FRFA$_t$*Eligible$_i$, is positive and significant. Regression
Table 4: Eligibility Premium. (I) Eligibility Premium estimation, FRFA represents announcement date; (2) Eligibility Premium estimation with time varying fixed effects, FRFA represents announcement date; (III) Eligibility Premium estimation, FRFA represents implementation date; (IV) Eligibility Premium probability model (OLS); (V) Eligibility Premium probability model (OLS) with time varying fixed effects. Equations (1) and (2), respectively. \( p_{ibt} \) is the nominal price paid by bank \( b \) for security \( i \) on day \( t \); \( \rho_{ibt} \) takes the value of 1 if bank \( b \) buys security \( i \) on day \( t \), -1 if it sells, and zero otherwise; FRFA\( t \) takes the value of 1 after its announcement on October 8th, 2008 and zero otherwise; ECB\(_{funding} \) is the ratio of ECB funds to total assets; Eligible\( _i \) takes the value of 1 if asset \( i \) is eligible as collateral. Variables with subscript \( t \) are defined daily. Standard errors in parentheses and clustered in the bank-security dimension. * \( p < 0.10 \), ** \( p < 0.05 \), *** \( p < 0.01 \). Autocorrelation gives the p-value for the Wooldridge (2010) test for autocorrelation in panel data, where \( H_0 \) is autocorrelation.

<table>
<thead>
<tr>
<th></th>
<th>(I)</th>
<th>(II)</th>
<th>(III)</th>
<th>(IV)</th>
<th>(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p_{ibt} )</td>
<td>0.347***</td>
<td>1.597**</td>
<td>0.230***</td>
<td>0.005**</td>
<td>-0.003</td>
</tr>
<tr>
<td></td>
<td>(0.069)</td>
<td>(0.747)</td>
<td>(0.072)</td>
<td>(0.002)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>( \rho_{ibt} )</td>
<td>-0.331***</td>
<td>-1.662***</td>
<td>-0.326***</td>
<td>-0.008***</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>(0.078)</td>
<td>(0.747)</td>
<td>(0.083)</td>
<td>(0.002)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>log(Order Size(_{ibt} ))</td>
<td>-0.020***</td>
<td>-0.020***</td>
<td>-0.007***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>liquidity(_it)</td>
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<td>-0.001***</td>
<td>-0.0001***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S&amp;P 500(_{t-1})</td>
<td>0.0003*</td>
<td>0.0003*</td>
<td>-0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIX(_{t-1})</td>
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<td>-0.003**</td>
<td>0.0000</td>
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<tr>
<td></td>
<td>(0.001)</td>
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<td></td>
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<tr>
<td>euribor1M(_{t-1})</td>
<td>-0.017</td>
<td>-0.029</td>
<td>-0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.072)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>euribor3M(_{t-1})</td>
<td>1.522***</td>
<td>1.432***</td>
<td>0.042***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.196)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>euribor1Y(_{t-1})</td>
<td>-2.142***</td>
<td>-2.098***</td>
<td>-0.044***</td>
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<td></td>
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<tr>
<td></td>
<td>(0.192)</td>
<td></td>
<td></td>
<td></td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bank-Week FE</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Security-Week FE</td>
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<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Autocorrelation</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>adj. within R(^2)</td>
<td>0.894</td>
<td>0.242</td>
<td>0.894</td>
<td>0.007</td>
<td>0.013</td>
</tr>
<tr>
<td># Obs</td>
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<td>177,413</td>
<td>197,318</td>
<td>3,307,262</td>
<td>3,375,526</td>
</tr>
</tbody>
</table>
(V) shows that this effect cannot be identified within the week of the policy announcement, i.e. the coefficients are not significant.

Regressions (I) and (III) present a relatively high $R^2$. A common concern regarding estimations with high $R^2$ is the serial correlation of the error term. I address this issue with the Wooldridge (2010) test for autocorrelation in panel data. In the last line of Table 5, the p-value of the test is presented. There, we find that the inclusion of the AR(1) process excludes the possibility of autocorrelation at the 5% confidence level.

In summary, this section concludes that, after the introduction of FRFA tenders, collateral assets became more expensive and banks were more likely to buy them.

### 4.3 Anticipation Effect

The difference-in-differences empirical strategy is based on the idea that the causality is due to the treatment, the implementation of FRFA tenders. If agents anticipate the actions of the ECB before its introduction, they may react before the announcement and the coefficient of the regression could be underestimated. Therefore, I estimate Equation (1) using placebo treatment dates: 21, 14, and 7 days before and the actual announcement of the policy. In this case, I restrict the sample until the day of the policy announcement (8th of October). Similarly, to test whether the effect vanishes with time I estimate Equation (1) using placebo treatment 21, 14, and 7 days after the actual announcement of the policy.

![Figure 2: Eligibility Premium Anticipation Effect](https://example.com/figure2.png)

**Figure 2: Eligibility Premium Anticipation Effect.** Coefficients of interaction term $\text{FRFA}_t \times \text{eligible}_i$ using placebo dates for $\text{FRFA}_t$. Coefficients from $\{t-21, t-14, t-7\}$ are not significantly different from zero at the 10% confidence interval. Coefficients from $\{t, t+7, t+14, t+21\}$ are significantly different from zero at the 10% confidence interval. Source: own calculation.

Figure 2 presents the coefficient of the interaction term, $\alpha_1$, for estimations described above. The figure shows that up to 7 days before the actual policy implementation eligible assets were not significantly more expensive than ineligible. In fact, the coefficients of t-21, t-14, and t-7 are not statistically significant at the 10% level. After the announcement
the coefficient increases and remain above 20bps. Interestingly, the coefficients of t+7, t+14 and t+21 are statistically significant at the 10% level, suggesting that the effect is persistent. Figure 2 presents no evidence for an anticipation of the Eligibility Premium.

5 The Fire Buy Premium

5.1 Empirical Strategy

The previous section established that eligible collateral assets become more expensive with unlimited central bank liquidity provision. This section expands the analysis in the cross section of banks. More specifically, I investigate if banks that are more reliant on the ECB to refinance, face price discrimination.

In OTC markets, banks' bargaining power is determined by their outside option to trade, commonly measured by bank’s centrality in the trading network. Li and Schürhoff (2014) as well as Di Maggio et al. (2017) show that because dealers are central in the network they have better economic outcomes. Conversely, non-dealers pay higher price when buying and receive lower price when selling. In this study, I argue that unlimited central bank liquidity provision also affects banks’ bargaining power.

To disentangle the weaker from the stronger party in the bargaining process I need to separate buy and sell transactions. This separation is necessary because the loss of bargaining power implies that agents will have worse economic outcomes in both type of transaction, i.e. pay more when buying and receive less when selling. A joint estimation would potentially cancel out both effects. In this section, I focus on purchase orders because they describe banks’ willingness to pay for collateral assets, which is a clear indicator of banks’ lost of bargaining power.

To capture banks’ willingness to pay, I use a special feature of my dataset, the identification of buyers and sellers. For every transaction I can identify whether the trade is a buy or a sell from the perspective of the reporting bank. I select a subsample of buy orders and estimate Equation (3). Furthermore, I investigate if these banks pay materially more when buying lower rated collateral assets. I divide the securities in the analysis by rating (AAA, AA, A, and BBB). In Section 8, I present the results using sell orders as a falsification test. For each rating category I estimate an interaction between the treatment and ECB funding, as follows:

\[
p_{ibt} = \gamma_1 FRFA_t \times ECBfunding_{bw} + \gamma_2 FRFA_t + \gamma_3 ECBfunding_{bw} + \Pi W_{ibt} + \eta_{pst-1} + \Delta_i + \Delta_b + \Delta_w + \epsilon_{ibt} \tag{3}
\]

where \( ECBfunding_{bw} \) is the ratio of central bank liabilities to total liabilities of bank \( b \) in week \( w \).

In Equation (3) the coefficient of the interaction term, \( \gamma_1 \), represents how reliance on ECB funds influences the premium payment after the introduction of FRFA tenders, the Fire Buy Premium.

According to Table 1, banks more reliant on central bank liquidity also have poorer access to interbank markets and need to close their funding gap using ECB funds. Thus, in the present context, central bank funding is an indicator of how distressed a bank is.
In order to illustrate the Fire Buy Premium, I present Figure 3. It shows the mean price of BBB-rated collateral paid by the two group of banks described in Section 3.2. Until October 2008, the ECB Dependent group pays consistently less than the Non ECB Dependent group. After the introduction of FRFA this figure reverses and the ECB Dependent group pays more in November and December. This movement illustrates my identification strategy for the Fire Buy Premium; with unlimited central bank liquidity banks more reliant on ECB funds have lower bargaining power and pay higher prices for collateral assets.

5.2 Results

Table 5 presents the estimation of Equation (3) for the four rating categories with standard errors clustered on the bank-security dimension. As alternative specification, each equation is estimated using time varying fixed effects in the bank and security dimension. In all regressions, the variable of our primary interest is the interaction between the ratio of central bank funds to total liabilities (ECBfunding$_{bw}$) and the dummy representing the introduction of fixed-rate full allotment tenders (FRFA$_{t}$).

For all ratings, the interaction term is positive and significant, i.e. banks more reliant on the ECB pay a premium to acquire collateral assets. I quantify the Fire Buy Premium as the difference between the price paid by the mean bank in the ECB Dependent and the Non ECB Dependent groups. That is $27.2 \text{ bps} = (0.078 - 0.016) \times 4.397$ for AAA-rated assets, 8.4 for AA-rated assets, 6.3 for A-rated assets, and 18.5 for BBB-rated assets. In the alternative specification, using time-varying fixed effects, the Fire Buy Premium is only significant for BBB-rated assets. In this specification, the Fire Buy Premium is 39.8 bps, suggesting that in the short run the Fire Buy Premium was particularly strong for BBB-rated assets.

Regressions (I) and (II) present an estimation for AAA-rated collateral assets. The
Table 5: Fire Buy Premium, Equation (3). (I-II) AAA, (III-IV) AA, (V-VI) A, (VII-VIII) BBB. $p_{ibt}$ is the nominal price paid by bank $b$ for security $i$ on day $t$; FRFA$_t$ takes the value of 1 after its announcement on October 8th, 2008 and zero otherwise; ECBfunding$_{bw}$ is the ratio of ECB funds to total assets; and lagged prices are based on the interpolation of transaction prices from all banks. Variables with subscript $t$ are defined daily and $w$ weekly. Standard errors in parentheses and clustered in the bank-security dimension. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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<td>$p^{AAA}_{ibt}$</td>
<td>0.478</td>
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<td>2.98***</td>
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<td>(1.934)</td>
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<td>$p^{BBB}_{ibt}$</td>
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<td>(1.763)</td>
<td>(1.61)</td>
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<tr>
<td>FRFA$<em>t$*ECBfunding$</em>{bw}$</td>
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<td>Net Interbank$_{bw}$</td>
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<td>Interbank Liabilities$_{bw}$</td>
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<td>0.836</td>
<td>-1.082</td>
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<td>log(Total Assets$_{bw}$)</td>
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<td>(1.532)</td>
<td>(0.653)</td>
<td>(0.879)</td>
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<td>Equity Ratio$_{bw}$</td>
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<td>(2.112)</td>
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<td>Cash$_{bw}$</td>
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<td>(1.532)</td>
<td>(0.653)</td>
<td>(0.879)</td>
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<td>log(Order Size$_{ibt}$)</td>
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<td>S&amp;P 500$_{t-1}$</td>
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<td>(0.002)</td>
<td>(0.004)</td>
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<td>VIX$_{t-1}$</td>
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<td>Euribor 1M$_{t-1}$</td>
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<td>Euribor 3M$_{t-1}$</td>
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Security FE | Yes | No | Yes | No | Yes | No | Yes | No |
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Bank-Week FE | No | Yes | No | Yes | No | Yes | No | Yes |
Security-Week FE | No | Yes | No | Yes | No | Yes | No | Yes |
AR(1) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
adj. within R$^2$ | 0.023 | 0.268 | 0.925 | 0.273 | 0.925 | 0.229 | 0.905 | 0.162 |
adj. within R$^2$ | 0.023 | 0.268 | 0.925 | 0.273 | 0.925 | 0.229 | 0.905 | 0.162 |
adj. within R$^2$ | 0.023 | 0.268 | 0.925 | 0.273 | 0.925 | 0.229 | 0.905 | 0.162 |
adj. within R$^2$ | 0.023 | 0.268 | 0.925 | 0.273 | 0.925 | 0.229 | 0.905 | 0.162 |
adj. within R$^2$ | 0.023 | 0.268 | 0.925 | 0.273 | 0.925 | 0.229 | 0.905 | 0.162 |
coefficient of the interaction term is the highest among all rating categories. This result relates to the fly-to-quality effect (see e.g. Beber, Brandt, and Kavajecz (2009) and Ivashina and Scharfstein (2010)), which suggests that during financial crisis banks adjust their security holdings towards higher quality assets. The Fire Buy Premium adds price discrimination to this literature line; when flying to quality banks with difficulty to refinance themselves pay a premium.

In regressions (III) and (V), the coefficient for AA- and A-rated assets is decreasing in economic and statistic significance. This is because those assets are dominated in terms quality by AAA-rated ones, and in terms of haircut subsidies by BBB-rated ones.

Interestingly, the coefficient of regression (VII), BBB-rated assets, is economically and statistically more significant than for AA- and A-rated assets. Banks are willing to incur an extra premium to buy BBB-rated assets because the risk-shifting channel is specially prone for them. The difference in haircut applied to those assets is explained in the Appendix.

Although bank control variables are defined weekly, each of them is significant in at least one regression. Banks with negative net position in the interbank market, Net Interbank$_{bw} < 0$, also pay more for collateral assets (AAA). Bank size, log(Total Assets$_{bw}$), equity ratio, and cash holdings are related to lower prices (AA). The size securities portfolio, Security Holdings$_{bw}$, is positively related with the price of BBB rated assets.

The disaggregated estimation evidences that securities prices react differently to the control variables depending on their rating. Larger order sizes are related to higher prices for AAA- and AA-rated assets. Assets traded more frequently are more expensive if AAA-rated and cheaper if AA- or A-rated. AAA- and AA-prices are negatively related to S&P 500. Short-term interest rates (1M and 3M) are positively related to prices of all rate buckets, whereas medium term interest are negatively related.

The existence of the Eligibility and the Fire Buy Premia suggest two confounding effects. The possibility of raising unlimited liquidity from the central bank and the scarce provision of collateral assets increases the price of these securities. Moreover, because collateral assets are fixed-income securities traded over-the-counter price discrimination occurs. Banks more reliant on the ECB to refinance themselves have lower bargaining power and pay higher prices to buy collateral assets.

In order to avoid a shortage of collateral assets and mitigate the Eligibility Premium, the ECB enlarged its collateral framework to accept BBB-rated assets. However, the haircut applied to these assets does not cover all risks related to the transaction. Banks exploiting the haircut subsidy incur even higher premium to acquire BBB-rated collateral assets. At the limit, we can interpret the Fire Buy Premium for BBB-rated assets as how much a bank can increase its yield by pledging the particular asset and shifting the extra risk to the ECB. Hence, it prices gains from the risk-shifting mechanism.

### 5.3 Anticipation Effect

In this section, I test whether banks could anticipate the price discrimination and potentially start buying assets before the policy implementation. Here, I focus on BBB-rated assets because they are the main result of this section.

In the study, I use FRFA as treatment to identify the Fire Buy Premium. However, BBB-rated assets only became eligible as collateral one week later on the 15th October.
Figure 4 shows the estimated coefficients of \( \gamma_1 \) in Equation 3 for \{t-21, t-14, t-7, t+7, t+14, t+21\} placebo dates. On the date of the FRFA announcement the coefficient jumps in magnitude and significance, suggesting that at this point agents were expecting the ECB to enlarge its collateral framework, an anticipation. The anticipation in this case is so clear that I decide to use FRFA as actual treatment, because otherwise my results could be biased.

![Graph showing coefficients](image)

Figure 4: **Risk-Shifting Premium Anticipation Effect.** Coefficients of interaction term \( \text{Expansion}_t \times \text{ECBFunding}_{bw} \) using placebo dates for \( \text{Expansion}_t \). Source: own calculation.

Before the treatment, the coefficients of the placebo estimations seem random, and are not statistically significant at the 10% level, which suggests no anticipation effect. After the FRFA implementation, the coefficient decreases gradually, suggesting a persistent effect.

### 6 Who is Providing Collateral Assets?

In this study, I describe how the ECB lender of last resort policy increased banks demand for collateral assets. Thus, the immediate question is: who provides these assets?

To answer this question I analyze the counterparties of each trade. For each transaction of the 26 banks in my sample I also have an identification code for the counterparty. The field is left empty if the counterparty has no report requirement (5.14% of the cases before FRFA, and 20.17% after).\(^\text{16}\) Moreover, for the counterparties that I can uniquely recognize their identification code, I cannot identify who they are and match with their balance sheet. Thus, my analysis consists on identifying how frequently some traders provided banks in my sample with eligible collateral assets.

Over the course of 2008, the 26 banks in my sample bought eligible assets from 1941 counterparties; 1789 before fixed-rate full allotment tenders, and 1339 after. This reduc-

\(^\text{16}\)This is normally the case for foreign institutions not regulated in Germany.
tion is a first indicator that less traders were willing to participate in the market in a period where the demand for those assets increased.

Further, I analyze the largest traders providing eligible collateral assets by volume. For this end, I add the market share of the largest 10 counterparties. Before the implementation of fixed-rate full allotment tenders this group of traders made 25.2% of the market compared to 45.4% after. In other words, after FRFA the provision of collateral assets became more concentrated among a few asset providers.

Lastly, there were five counterparties that were ranked persistently among the top 10 before and after FRFA. All of these five counterparties are not in the group of 26 German banks in my sample. This result suggest that top providers of collateral assets increased their market share after FRFA filling the gap left by others.

The three pieces of evidence suggest that fewer traders were willing to provide eligible collateral assets after FRFA, and some participants that were well positioned in the market before FRFA took opportunity to increase their market share after FRFA.

7 Quantity Analysis

So far, my analysis has focused on the price effect of the ECB liquidity provision. In this section, I briefly describe how fixed rate full allotment tenders impacted the quantity of collateral traded and held by banks. In the first part of the analysis, I accumulate all orders of eligible assets over time to investigate which bank group is net buyer and seller. In the second part, I analyze how much eligible collateral assets banks hold in their balance sheet as share of total assets.\(^{17}\)

Figure 5: Net Cumulative Position of eligible assets. Calculated as \(\sum_t \sum_i (\text{buy vol}_{it} - \text{sell vol}_{it})\), where \(\text{vol}_{it} = p_{it} \cdot q_{it}\), where \(p\) is price and \(q\) quantity.

Figure 5 shows the banks’ cumulative position on all eligible collateral assets (buy

\(^{17}\)The dataset on bank trading is provided by the BaFin, the dataset on banks’ asset holdings by the Bundesbank. For this reason the results do not perfectly match. This mismatch is due different legal definition of the reporting institutions.
minus sell over time). If the value is positive, banks have bought more collateral assets than they sold. If it is negative, banks sold more. Similarly as before, I call banks with ECB funding above the median *ECB Dependent* and the ones below *Non ECB Dependent*.

Figure 5 points that, until mid 2008, both bank groups were slightly liquidating their exposure to ECB collateral assets in similar manner. Between June and August, Non ECB Dependent increased their exposure, while ECB Dependent decreased. In September, with the Lehman Brothers event, ECB Dependent did not increase its exposure to ECB collaterals substantially. Only in October, when the ECB acted as lender of last resort that these banks became substantial net buyers. Non ECB Dependent were net sellers of collateral assets in September and October, and net buyers in November and December. Overall, the change in net positions is consistent with previous results: ECB Dependent banks need collateral assets to cover their short term liquidity need. They buy more collateral even if these securities become more expensive and they face price discrimination.

![Figure 6: Holdings of Eligible Collateral Assets as share of total assets. ECB Dependent: black line. Non ECB Dependent: dashed line. Source: Bundesbank, own calculation.](image)

In order to put the above described picture into perspective of banks’ balance sheet. Figure 6 presents the total holdings of eligible collateral assets as share of balance sheet size (average across banks). I use the Security Holdings Statistics of the Deutsche Bundesbank (Bade, Flory, and Schoenberg (2016)), a quarterly data set that contains all asset holdings (security-by-security) of all 26 banks (bank-by-bank). For each bank, I sum up the holdings of all eligible collateral assets and divide by their total assets, i.e. the share of eligible assets to total assets. Figure 6 shows banks’ average collateral holding by the two groups: ECB Dependent (black line), and Non ECB Dependent (dashed line). Non ECB Dependent has a slight increase in collateral holdings over the observation window. ECB Dependent has a more volatile curve. In the first half of 2008, the movements in the figure was mainly due to changes in banks’ balance sheet size since they did not increased their net position in the secondary market substantially (see Figure 5). In the second half of 2008, ECB Dependent banks increased their holdings of eligible collateral assets from about
24% of their balance sheet to about 33%. In summary, when the EXB provides unlimited liquidity banks hoard collateral assets because they have same liquidity features as cash but yield positive return.

8 Falsification Tests

In this section, I present supporting evidence for the causal effect of the treatment, $FRFA_t$. I address four issues using falsification tests. First, is the network structure of OTC markets (dealers vs non-dealers) influencing my results? Second, are the results driven by the fact that I am looking only into buy orders? Third, is the definition of the variable $ECBfunding$ driving my results? Fourth, are the results driven by the Lehman Brothers bankruptcy about a month before the ECB’s actions?

8.1 Dealer-Non-Dealer Structure of OTC Markets

In over-the-counter markets, price differentiation occurs according to the network structure of the market. Periphery participants (non-dealers) pay a premium to trade with the core (dealers); see e.g. Li and Schürhoff (2014), and Di Maggio et al. (2017). In order to disentangle a premium payment attributed to the network structure from the proposed premia I identify trades in which dealers are the counterparty. For each trade I am able to identify both counterparties. Thus, I determine for each security the trader that has been the most frequent counterparty in my sample. I create a dummy variable called $Dealer_{i-b}$ that takes the value of 1 whenever the counterparty of the trade is the largest counterparty of the specific asset. Further, I interact the variable $Dealer_{i-b}$ with the interaction terms in Equation (1) and (3).

Table 6 presents the results. Regression (I) shows the Eligibility Premium interacted with the dealer dummy, whereas Regressions (II)-(V) present the Fire Buy Premium interacted with the dealer dummy. Overall, I find no evidence that the dealer-non-dealer structure of OTC markets drive my results because my main results hold: $FRFA_t*Eligible_i$ and $FRFA_t*ECBfunding_{bw}$ are positive and significant.

Also, we find that trading with a dealer leads to a premium payment, positive and significant coefficient of the variable $Dealer_{i-b}$ in Regressions (II), (IV) and (V). The insignificance of the dealer variable in (I) is related to the use of buy and sell orders in the same estimation. If banks pay a premium to buy from a dealer and sell at a discount, the joint estimation cancels out both effects.

In summary, I find no evidence that the dealer-non-dealer structure of OTC markets is responsible for the effects described in this study.

8.2 Sell Side of the Market

The Fire Buy Premium identification strategy is based on the buy side of each trade with collateral assets. Similarly as described in the previous section, estimating sell and buy orders jointly would cancel out the effect. This is because lower bargaining power lead to worse economic outcome, banks buy at premium and sell at discount. Selling at

\footnote{The subscript $-b$ represents the counterparty of bank $b$ in a given trade.}
Table 6: Falsification Test – Dealer-Non-Dealer Structure of OTC Markets:
(I) Fire Buy premium with identification of dealers, (II-V) Risk-Shifting premium with identification of dealers. Dealer<sub>i</sub>−<sub>b</sub> takes the value of 1 when counterparty −<sub>b</sub> is the largest counterparty of asset <sub>i</sub> in the sample; <sub>p</sub><sub>ibt</sub> is the nominal price paid by bank <sub>b</sub> for security <sub>i</sub> on day <sub>t</sub>; FRFA<sub>t</sub> takes the value of 1 after its announcement on October 8<sup>th</sup>, 2008 and zero otherwise; ECBfunding<sub>bw</sub> is the ratio of ECB funds to total assets; Eligible<sub>i</sub> takes the value of 1 if asset <sub>i</sub> is eligible as collateral.LnL. Variables with subscript <sub>t</sub> are defined daily and <sub>w</sub> weekly. Standard errors in parentheses and clustered in the bank-security dimension. * <i>p</i> < 0.10, ** <i>p</i> < 0.05, *** <i>p</i> < 0.01.

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<td>1.89</td>
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<td>-1.32</td>
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<td>(0.136)</td>
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<td>0.063</td>
<td>-0.863*</td>
<td>0.010</td>
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Security Controls   Yes Yes Yes Yes Yes
Bank Controls       No Yes Yes Yes Yes
Bank FE             No Yes Yes Yes Yes
Security FE         Yes Yes Yes Yes Yes
Week FE             No Yes Yes Yes Yes
Bank-Week FE        Yes No No No No
AR(1)               Yes Yes Yes Yes Yes
adj. within R²      0.894 0.027 0.918 0.925 0.905
# Obs               197,318 58,762 23,776 16,344 9,010
Table 7: Falsification Test – Sell Positions: (I-IV) Fire Buy Premium using sell positions by rating category. $p_{ibt}$ is the nominal price paid by bank $b$ for security $i$ on day $t$; $FRF_{t}$ takes the value of 1 after its announcement on October 8\textsuperscript{th}, 2008 and zero otherwise; $ECBfunding_{bw}$ is the ratio of ECB funds to total assets. Variables with subscript $t$ are defined daily and $w$ weekly. Standard errors in parentheses and clustered in the bank-security dimension. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

<table>
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<th>(I) $p_{ibt}^{AAA}$</th>
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<th>(III) $p_{ibt}^{A}$</th>
<th>(IV) $p_{ibt}^{BBB}$</th>
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<td>$FRF_{t} \times ECBfunding_{bw}$</td>
<td>-0.355 (0.299)</td>
<td>1.38* (0.798)</td>
<td>-2.31** (1.14)</td>
<td>-2.78* (1.46)</td>
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<td>$ECBfunding_{bw}$</td>
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<td>$FRF_{t}$</td>
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<td>71,328</td>
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Table 8: Fire Buy Premium with Dummies, Equation (3). (I) AAA-rated, (II) AA-rated, (III) A-rated, (IV) BBB-rated. $p_{ibt}$ is the nominal price paid by bank $b$ for security $i$ on day $t$; FRFA$_t$ takes the value of 1 after its announcement on October 8th, 2008 and zero otherwise; ECBdependent$_{bm}$ equals one if the ratio of ECB funds to total assets is above the median in month $m$, and zero otherwise; and lagged prices are based on the interpolation of transaction prices from all banks. Variables with subscript $t$ are defined daily, $m$ monthly. Standard errors in parentheses and clustered in the bank-security dimension. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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Table 9: Falsification Test – Lehman Brothers Bankruptcy: (I) Eligibility Premium estimation with Lehman treatment; (II-V) Fire Buy Premium estimation by rating category with Lehman treatment. Lehman_t takes the value of 1 after its bankruptcy on September 14th and zero otherwise; \( p_{ibt} \) is the nominal price paid by bank \( b \) for security \( i \) on day \( t \); \( ECBfunding_{bw} \) is the ratio of ECB funds to total assets; FRFA_t takes the value of 1 after its announcement on October 8th, 2008 and zero otherwise; Eligible_i takes the value of 1 if asset \( i \) is eligible as collateral. Variables with subscript \( t \) are defined daily and \( w \) weekly. Standard errors in parentheses and clustered in the bank-security dimension. * \( p < 0.10 \), ** \( p < 0.05 \), *** \( p < 0.01 \).

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<td>( p_{AA}^{ibt} )</td>
<td>( p_{A}^{ibt} )</td>
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<td>FRFA_t*Eligible_i</td>
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<td>FRFA_t*ECBfunding_{bw}</td>
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<td>1.78* (0.768)</td>
<td>0.846 (0.721)</td>
<td>2.67** (1.16)</td>
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<td>Lehman_t</td>
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<td>-0.049 (0.095)</td>
<td>0.105 (0.075)</td>
<td>0.264* (0.160)</td>
<td>0.005 (0.072)</td>
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<td>FRFA_t</td>
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<td>-0.595*** (0.107)</td>
<td>-0.163** (0.061)</td>
<td>-0.367*** (0.117)</td>
<td>-0.327** (0.159)</td>
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discount in periods of great need of collateral seems less intuitive. However, banks could be adjusting their portfolio within a given rating category. In other words, I answer the question: given the decision to sell an asset how does the loss in bargaining power affects the outcome.

Hence, I estimate Equation (3) using only sell orders. Table 7 presents the results.

The results are blurred. In Regression (I), the coefficient of the interaction term $FRFA_t \times ECBfunding_{iw}$ is insignificant. In Regression (II), it is positive and significant at the 10% confidence level. Conversely, in (III) and (IV) the coefficients are negative and significant at the 5% and 10% confidence levels, respectively.

Overall, the effect of a loss in bargaining power on the economic outcome is much less clear on the sell side. Nevertheless, it is still possible to say that the loss of bargaining power lead banks to sell their collateral assets at a discount.

8.3 Definition of the Central Bank Funding

The identification of the Fire Buy Premium is based on the dependence of banks on ECB funding. Therefore, I use the amount of ECB funding as share of balance sheet as indicator for banks’ loss in bargaining power. If for some reason, there is a inertia, where banks that hold more collateral assets also buy more, my results could be biased. Also, the variable $ECBfunding$ is defined monthly and interpolated into weekly values, some may argue that this transformation may also affect my results.

In order to address both concerns regarding the definition of $ECBfunding$ I present an alternative estimation. I estimate Equation (3) using $ECBdependent$ instead of $ECBfunding$. $ECBdependent$ is defined as described in 3.2, and equals one if the bank dependence is above median in a given month. The results are presented in Table 8.

The results are consistent in terms of significance and magnitude. Thus, I conclude that my results are not driven by the definition of $ECBfunding$.

8.4 Lehman Brothers Bankruptcy

The Lehman Brothers bankruptcy was such an important event during the observation window that I test the possibility that some of my results may have been driven by this event. Hence, I propose an estimation including the bankruptcy as a further treatment in the interaction models described by Equations (1) and (3). Therefore, I define a dummy called $Lehman_t$ that takes the value of 1 after September 14th and interact it with the previous variables. Note that there is no three-way interaction term because $FRFA_t \times Lehman_t = FRFA_t$. The estimations are presented in Table 9.

In Estimation (I), the coefficients of the interaction terms $Lehman_t \times Eligible_i$ is negative and significant, whereas $FRFA_t \times Eligible_i$ is positive and significant, suggesting that Lehman had an opposite impact on collateral prices. The explicit identification of the Lehman event increases the economic significance of the estimation. Thus, I conclude that Lehman Brothers bankruptcy is not the major driver of the Eligibility Premium.

In Estimations (II)-(V), the interaction term $Lehman_t \times ECBfunding_{bw}$ are non-significant. Therefore, I find no evidence that the Lehman Brothers bankruptcy is the driver of the Fire Buy PRemium.
9 Conclusion

In the present study, I describe the impact of unlimited central bank liquidity provision on the secondary market for collateral assets. In order to avoid fire sales the ECB provided unlimited liquidity, which makes central bank collateral assets more valuable than cash and banks paid the Eligibility Premium. It demonstrates that banks pay more for collateral assets in times when central bank liquidity is most needed and underlines the necessity of an expansion of the collateral framework.

Unlimited central bank liquidity provision also affects banks’ bargaining power. Banks more reliant on ECB funds have lower outside option to trade and are price discriminated. They incur a Fire Buy Premium, which quantify how much banks reliant on ECB funds pay more for collateral assets compared to less reliant banks.

In order to avoid a shortage of collateral securities, the ECB lowered the quality threshold to accept BBB-rated collateral assets. However, the haircut applied to these assets did not reflect the risk of the operation, encouraging banks to shift risks to the ECB balance sheet. This risk-shifting feature leads banks to pay a specially high Fire Buy Premium for BBB-rated assets. It represents how much banks can increase their yields using haircut subsidies. Moreover, it shows that haircut subsidies as form of financial support is not efficient because the financial support does not remain with the intended banks. Hence, my study links monetary policy to trading behavior and adds to the risk-shifting literature.

If haircuts perfectly reflected securities’ risk and the correlation risk between collateral and counterparty, banks would be indifferent about which asset to pledge. In this way, an enlargement of the collateral framework merely means an enhancement of liquidity provision, and the risk-shifting channel would be close. More differentiation between counterparties, which takes into account the correlation risk between collateral and counterparties, could solve the problem. However, a haircut policy that takes discretionary decisions on a transaction-by-transaction basis is not feasible because the estimation of the correlation risk between counterparties and collateral is nontrivial since there are over 30,000 eligible collateral assets and 1,000 counterparties in the Eurozone.

My results are drawn from a sample of 26 German banks and thus relate only to a small subsample of European banks. However, the ECB Collateral Framework applies to all banks in the Eurosystem, and the risk-shifting channel is open to all of them. Hence, the phenomenon described in this study may occur with other banks as well. I leave this issue to be determined by future research.

I make use of one specific identifying shock, the implementation of full allotment tenders. However, scarcity of collateral assets and a disputable haircut setting could occur in other situations. For instance, the asset purchase program in early 2011 may have induced banks to acquire collateral assets because they knew the ECB would buy them. I leave the investigation of this period to further research as well.
Appendix

The ECB Collateral Framework

The *ECB Collateral Framework* is a guideline for the implementation of monetary policy in the euro zone. The framework is relatively broad in all its dimensions; see Eberl and Weber (2014), Nyborg (2017), ECB (2003), ECB (2005), ECB (2006), ECB (2008a), ECB (2008b). First, it permits several categories of debt instruments: corporate bonds, government bonds, covered bonds, uncovered bank bonds and ABSs. Second, the quality threshold is relatively loose; until October 2008 bonds had to be rated A- or better, and thereafter BBB- or better. Third, the number of counterparties is relatively large; as of January 2011, 3,211 financial institutions had access to the ECB funds market.

To mitigate security risks, the ECB applies a haircut to the asset value according to Table 10. Haircuts increase with maturity, non-coupon payment, and category. In contrast to the private markets, the ECB does not take into account the correlation between collateral risk and counterparty. For instance, an Austrian and a Portuguese bank of similar rating might receive different haircuts in private repos when using a Portuguese sovereign bond as collateral. This differentiation happens because, in the scenario where Portugal is bankrupt, Portuguese banks are also likely to be bankrupt, whereas an Austrian bank would be less affected.

The ECB conducts open market operations predominantly via repos (repurchase agreements), but banks can also access central bank funds through the marginal lending facility. In both cases, banks need to pledge high-quality collateral. Unlike the Fed, where the primary dealer system is used, in the Eurosystem, a large number of banks can engage in transactions with the ECB.

Also in contrast to the US, where only Treasuries are accepted as collateral, the ECB allows a wider range of assets as collateral in four categories as described above. The definition of which securities are accepted as collateral depends on many factors including asset quality, type of asset, credit standard, place of issue, type of issuer, currency, asset marketability etc. The most notable characteristic is asset quality, which until October 2008 had to be a rating of A- or better, and BBB- or better thereafter.

Until October 2008, the ECB conducted variable-rate auctions, where participants had to submit bids for loan quantities at different interest rates. According to the aggregated demand for credit, the ECB determined the interest rate given the amount of liquidity it was prepared to supply. All bids above the clearing interest rate would be satisfied. Since October 2008, the ECB moved to a fixed-rate full allotment procedure in all its refinancing operations (Main Refinancing Operations or MROs; and Longer-Term Refinancing Operations or LTROs). This policy meant that banks can borrow any amount as long they have eligible collateral assets. In practical terms, the ECB became the lender of last resort.
Table 10: **Eurosystem haircuts** (in %) by liquidity category, residual maturity, and coupon (zero or fixed) in 2008. Category I: central government debt instruments, debt instruments issued by central banks; Category II: local and regional government debt instruments, Jumbo Pfandbrief, agency and supranational debt instruments; Category III: covered bonds, traditional Pfandbrief, credit institution debt instruments, debt instruments issued by corporates; Category IV: asset-backed securities. Note: with the expansion of the collateral framework, the ECB created a further category (uncovered debt) which is excluded from the analysis since I do not observe any trade with these assets. Source: Fecht et al. (2016).

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ECB Haircut Adjustment of 2011

In 2008, when the ECB expanded its Collateral Framework to accept BBB rated assets, it imposed a flat 5% haircut add-on compared to assets with similar maturity and category, see Table 10. However, as my study shows, this flat haircut add-on does not cover all risks related to this type of collateral. In its press release of 8th of April 2010, the ECB reviews its haircut policy and announces the introduction of a graduated haircut schedule. Table 11 presents the haircut increase in % points compared to Table 10.

In this adjustment, all revisions were related to BBB-rated collateral assets, and upwards (up to 19%), which evidences that previous haircuts were downwards biased.

Table 11: Haircut Change of 1st 2011 in % Category I: central government debt instruments, debt instruments issued by central banks; Category II: local and regional government debt instruments, Jumbo Pfandbrief, agency and Supranational debt instruments; Category III: covered Bonds, traditional Pfandbrief, credit institution debt instruments, debt instruments issued by corporates; Category IV: asset-backed securities. Note: with the expansion of the collateral framework, the ECB created a further category (uncovered debt) which is excluded from this table for simplicity. Source: ECB

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