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(Pro?)-cyclicality of collateral haircuts and systemic illiquidity

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Abstract

Procyclicality of collateral haircuts and margins has become a widely proclaimed behavior and is currently discussed not only by academic literature but also by regulatory authorities in Europe. Procyclicality of haircuts is assumed to be a trigger of liquidity spirals due to its tightening effect of collateral portfolio values in times of market distress. However, empirical evidence on this topic is quite sparse and the discussions are primarily driven by insights derived from theoretical models. Nonetheless, oversight bodies are discussing macroprudential haircut add-ons in order to curb with the potential effects of procyclicality in distressed periods. Based on a unique data set provided by a large European Central Counterparty we construct a measure of systemic illiquidity of bond collaterals and analyze the relationship between haircuts, the development of periods with explosive behavior and systemic illiquidity. We estimate the noise of bond yields to measure systemic illiquidity with and without considering haircuts. We then apply an explosive roots bubble detection technique to identify irrational periods of each of these two time series and to a combination of both. Finally, we propose a quantitative trigger and design for macroprudential haircut add-ons. Our results confirm that (1) bond collateral markets face irrational, i.e. bubble-like illiquidity during periods of systemic distress. The results indicate that (2) haircuts are not amplifying or increasing with systemic illiquidity. (3) The proposed haircut add-on mechanism exhibits desirable features to mitigate systemic illiquidity during lasting periods of distress.

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1 Introduction

Pro-cyclical tendencies of haircuts and margins are subject to an ongoing discussion among academics and regulatory authorities since the aftermath of the financial crisis in 2008. The basic line of argumentation is that in calm periods of the business cycle, lower margins (due to lower volatility of market prices) and lower collateral haircuts (due to low levels of illiquidity and counterparty risks) lead to an expansion of overall leverage and the value of collateral portfolios that can be used to secure positions. On the opposite, during times of financial distress the same effects work in the other direction and result in lower values of collateral portfolios, i.e. constraints of (funding) liquidity.

The value of collateral portfolios is subject to developments in prices as well as adjustments of collateral haircuts by the (central) counterparty. The higher the haircut on collateral securities pledged to meet margin requirements, the lower the value of the overall portfolio to collateralize positions. If margins and haircuts both increase during distressed periods, market participants collateralizing their positions with securities might be facing swings of collateral portfolio values exactly during times when increased margins and collateral haircuts are tightening their funding liquidity.

If funding liquidity deteriorates suddenly and sharply, i.e. a shock occurs, participants might be forced to liquidate positions, which increases volatility and hence margins. Others might be affected by rising margins and forced to sell in already falling markets, which might be further fuelling distress and result in pro-cyclical tendencies. These interacting effects, known as liquidity spirals and demonstrated in a theoretical model by Brunnermeier and Pedersen (2008), have a systemic character in form of market wide and exacerbated illiquidity and hence compromise financial stability. As a consequence, regulatory authorities call for (1) further investigation of this phenomenon, (2) through-the-cycle monitoring metrics and (3) have proposed macroprudential counter measures (ESRB, 2015). One measure is a counter-cyclical macroprudential add-on for collateral haircuts. Furthermore, counter measures to market wide illiquidity resulting from general loss of confidence in financial markets or exacerbated counterparty risk perceptions are called for in order to mitigate systemic tendencies (ESRB, 2013).

The vital discussion regarding potential procyclicality spirals was primarily stimulated by theoretical research which still serves as foundation for the discussion of macroprudential measures. Empirical research regarding procyclicality of collateral haircuts and its impact on market wide liquidity is sparse. From a historical perspective, an obvious reason is the lack of consolidated and comprehensive data from OTC derivatives markets. However, pushed by recent regulatory initiatives such as the European Market Infrastructure Regulation (EMIR), a large share of previously bilaterally traded and cleared products are or will be required to be centrally cleared. On the one hand, this development gives rise to new opportunities for regulatory authorities and academia to empirically investigate these data, e.g. with respect to procyclicality. On the other hand, central clearing of OTC derivatives concentrates the previously bilateral trades and the related risk in a few central entities. This development further increases the need for a comprehensive understanding of the forces at play from a macroprudential point of view.

With this work we aim to fill the gap of empirical insights regarding the relationship between market wide illiquidity and collateral haircuts. We propose a methodology that can serve as a quantitative and macroprudential trigger for haircut or margin add-ons. Our empirical approach consists of two steps: First, we leverage a recent measure of market wide illiquidity of collateral. Second, using a bubble detection methodology, we identify periods of irrational illiquidity which might serve as a trigger for macroprudential instruments. Based on this empirical setup we develop a methodology for macroprudential haircut add-ons which is quantitatively triggered as well as switched off by the bubble detection methodology.

The outline of our paper is as follows: We start with a brief review of theoretical and empirical arguments about procyclicality in general and procyclicality in the context of collateral haircuts. Subsequently, in section three, we introduce the theoretical frameworks and relationships underlying our empirical analysis. Section four first describes the data sets and explains the risk management methodology that prescribes the calculation of haircut variables. Afterwards, descriptive statistics of the data set as well as the results of our analysis are presented. In section five we discuss our findings in the context of policy recommendations and requirements. Section six summarises our work.

2 Background and Relevant Literature

Systemic risk is considered to build up in two dimensions: the structural and the cyclical dimension. The structural dimension refers to the interconnectedness of institutions via mutual exposures in trading and lending activities. The literature on the structural dimension is quite vast as compiled by Bisias et al. (2012). The cyclical dimension refers to financial market parameters (e.g. liquidity, haircuts, margins, leverage) being closely related to the business cycle and hence bearing an inherent risk to financial market stability (ESRB, 2015). There is no single, fully delineating definition or measure of procylicality. Various channels are known through which procyclicality can occur in each dimension. Furthermore, both dimensions are not fully separable as well (ESRB, 2013). Table 1 below provides an overview of definitions and characteristics of procyclicality.

Procyclicality Definitions	
Source	Definition of Procyclicality
Brunnermeier and Pedersen (2008)	'Intuitively, since liquidity risk tends to increase price volatility, and since uninformed financiers may interpret price volatility as fundamental volatility, this increases margins. This introduces a procyclicality that amplifies funding shocks.'
CGFS (2009)	'Changes in the financial system and in related market practices seem to have amplified business fluctuations and exacerbated financial instability during the current cycle.'
CGFS (2010)	'Margining practices can endogenously contribute to financial system procyclicality by easing (tightening) credit supply in the boom (downturn). In the upswing, a reduction in haircuts or initial margins increases the maximum leverage...'.
Adrian and Shin (2010)	'Leverage is high during booms and low during busts. That is, leverage is procyclical.'
ESRB (2013)	'The cyclical dimension is related to the tendency of banks to assume excessive risk in the upswing and become excessively risk averse in the downswing.'
BIS (2012)	'Procyclicality typically refers to changes in risk-management practices that are positively correlated with market, business, or credit cycle fluctuations and that may cause or exacerbate financial instability.'
Murphy et al. (2014)	'Broadly procyclicality refers to the tendency of any financial variable to move with the cycle.'
ESRB (2015)	'CCP models for setting margins and haircuts may create a positive correlation between price volatility and the level of margins or haircuts...'

Table 1: Definitions of procyclicality

According to ESRB (2015) the key channel of procyclicality of haircuts and margins resides in collateral portfolio asset price changes and market prices of financial instruments held by participants. This is in line with the perspective of BIS (2012, p. 47) who state that 'while changes in collateral values tend to be procyclical, collateral arrangements can increase procyclicality if haircut levels fall during periods of low market stress and increase during periods of high market stress.' Consequently, the following perspectives to analyze procyclicality of haircuts are chosen: On the one hand, we focus on prices of collateral and haircuts imposed by a central counterparty (CCP). On the other hand, we aim to take into account the procyclicality of collateral haircuts in the context of market wide illiquidity. In the first of the next two subsections we review theoretical foundations of haircut and margin procyclicality followed by empirical and anecdotal evidence for these theoretical relationships. Eventually, we derive our research hypothesis. The second subsection summarizes recently discussed requirements and recommendations for macroprudential counter-measures, i.e. haircut add-ons. This is relevant as we will compare our findings and our suggested quantitative systemic distress trigger to the requirements and proposed practices.

2.1 Procyclicality and Systemic Illiquidity

The most prominent theoretical work on this topic is proposed by Brunnermeier and Pedersen (2008). By linking market and funding liquidity they are able to demonstrate that a shock to funding liquidity conditions can induce speculators to reduce their position which increases volatility. This leads to higher margins and reduces traders' willingness to enter expensive liquidity positions resulting in deteriorating market liquidity. As a result, an adverse feedback loop can be triggered that can result in sudden spikes of market wide illiquidity. This endogenous process is also known as margin spirals. They further describe a loss spiral that is triggered by initial losses on large positions of speculators who are forced to increase collateral or reduce their positions, meaning they are selling into already falling markets and driving up volatility. Funding liquidity can be strained by increases in margins or haircuts on collateral (which they refer to interchangeably). Hence, their model endogenously links increases in haircuts and margins to sudden dry-ups of market wide liquidity and high levels of volatility.

Anecdotal evidence that is in line with the theoretical model is provided in CGFS (2010) 'The gradual erosion of lending terms during the period of high liquidity and low volatility was abruptly reversed when market conditions deteriorated. As valuation uncertainties for many structured products rose in 2007, haircuts on these securities were raised, forcing a few highly leveraged market participants to liquidate their holdings. A further significant and rapid tightening of the secured lending terms on a range of assets took place in 2008 that led to a contraction of the supply of secured financing and exacerbated deleveraging pressures.'

The Bank for International Settlements' report, "The role of margin requirements and haircuts in procyclicality" identifies collateral haircuts in securities financing transactions and margining practices in over-the-counter derivatives as one source of procyclicality in the financial system. Based on the example of the recent credit crisis, the report summarizes that in the time prior to the crisis, significant contributions to leverage stem from high availability of secured financing and low levels of haircuts. In the presence of central counterparties, supervisory approved risk-based models are applied to calculate collateral haircuts and product margins. Both are usually positively correlated with price volatility to protect the CCP against market price fluctuations. Besides, haircuts comprise a counterparty risk component reflecting the issuers creditworthiness as well as a liquidity component to take the ease of liquidation into account. Hence, it seems likely that margins and haircuts are higher in periods of high volatility and lower in periods of lower levels of volatility (ESRB, 2015).

To summarize, recent studies either base on theoretical models, empirical, regulatory or anecdotal evidence emphasize the critical role of funding liquidity for financial market stability. In particular, margins as well as haircuts can exacerbate funding liquidity conditions during distressed periods and contribute to high levels of leverage during calm phases.

Against this backdrop of theoretical and empirical propositions we formulate the following relationships. If the previously stated basic premises regarding procyclicality of bond collateral haircuts and systemic illiquidity are valid, the following relationships should be observable: During periods of distress, a co-movement of haircuts and price uncertainty should be observable. Given that prices are systematically falling and haircut levels are simultaneously rising, the ratio of both should lead to a non-linear effect for haircut adjusted prices. Hence, we hypothesize: if haircuts show a procyclical pattern and we compare market observed yields with yields resulting from prices that are haircut adjusted, the ratio of these two should develop in a non-linear fashion.

We will introduce an approach to test this hypothesis in section 3 and empirically validate it in section 4. The next section introduces proposed and considered approaches to monitor and mitigate pro-cyclical effects.

2.2 Counter-measures and Recommendations

Referring to existing models, CGFS (2010) state, however, that recommendations (for policy makers) are unclear due to the simplified and stylized nature of the models. They also point out that credit terms other than haircuts could adjust simultaneously and lead to different outcomes than predicted by the model. However, in more recent publications, the European Systemic Risk Board (ESRB), the Bank for International Settlements (BIS) as well as the Financial Stability Board (FSB) have proposed adjustments (i.e. macroprudential modifications) to haircuts and articulated desirable features of haircuts, future research directions and risk monitoring tools. A selection of these with respect to haircuts and systemic illiquidity is compiled in Table 2.

Mitigation of Procyclicality: Recommendations	
Source	Recommendation
CGFS (2009)	- Collect and track data on haircuts - Develop monitoring indicators of systemic funding risk
CGFS (2010)	- Not too conservative liquidity risk component (bid-offer spread) [for haircuts] - More conservative and stable haircuts across the cycle - Counter-cyclical add-on for (internationally coordinated) supervisory haircuts
FSB (2015)	- Numerical haircut floors - Countercyclical changes in minimum haircuts as macroprudential tool
ESRB (2013)	- Discretionary counter-cyclical add-on [...] when necessary - Haircuts imposed by supervisory authorities can curb financing booms and dampen the contraction of secured funding.
ESRB (2015)	- Provide authorities with macroprudential instruments that allow for adjusting margins and haircuts to address the systemic risks arising from procyclicality. - Instruments activated and adjusted solely on the basis of indicators and threshold values to calibrate intervention, which mitigates the risk of inaction bias.

Table 2: Recommendations to mitigate procyclicality

In summary, haircuts should be stable through the (credit/business) cycle and take into account counterparty as well as liquidity risks with sufficient lookback and stress period considerations. On a discretionary basis, supervisory or macroprudential haircut add-ons are considered a possible but hard to implement approach to mitigate funding strains during bust cycles. Vice versa, during benign market periods, constraints on the extension of funding by minimum haircuts are recommended. Furthermore, monitoring indicators for systemic funding risk are called for. Finally, macroprudential instruments for haircuts to address systemic risk as well as indicators and threshold values to trigger/calibrate these interventions are valid considerations.

2.3 Macroprudential Haircut Add-On

By reviewing relevant literature about requirements for macroprudential haircut add-ons, we conclude that only a little amount of very vague requirements are available. Nevertheless, CGFS (2010) state that a supervisory haircut add-on should be based on two different components. One reflecting a market component over a long historical time period and another reflecting a liquidity component. It is also mentioned that 'haircuts must be calculated in a conservative manner to limit pro-cyclical effects as far as possible' (ESRB, 2015, p. 11). Due to the fact that the first component is, to some extend, already incorporated by the haircut design of the central counterparty we analyse (see section 4.2, we focus on a second, additional component which is triggered in periods of financial distress and is based on a systemic illiquidity measure. In addition and in contrast to ESRB (2013) we raise the requirement that this macroprudential add-on should be based on a quantitative trigger instead of being based on a discretionary decision. This cancels out human decision making uncertainties and biases, which, in any case, should be based on a decent date driven analysis. How this is achieved is explained in section 4.5

The next section will introduce our approach to measure systemic illiquidity of collateral securities and propose the application of a procedure to determine the beginnings of irrational periods, i.e. the bust phase of the business cycle.

3 Methodology

In this chapter the theoretical framework as well as the general methodology of the test procedures are introduced. Our proposed methodology comprises three successive steps: Deriving a theoretical yield for EUR-denominated fixed income collateral securities (3.1), measuring systemic illiquidity (3.2) and identifying irrational behavior (3.4).

3.1 Theoretical Yields of Collateral Bonds

In order to derive theoretical prices for collateral bonds we generally stick to the procedure of Hu et al. (2013). However, instead of manually bootstrapping a yield curve from bonds we construct an interest rate curve from data published in the Statistical Data Warehouse of the European Central Bank. The interest rate curve provided by the European Central Bank is estimated with the model proposed by Svensson (1994) and hence in line with the approach of Hu et al. (2013). Svensson (1994) finds that his extension of the model proposed by Nelson and Siegel (1987) is more flexible regarding complex shapes of the term structure and hence achieves lower estimation errors which is desirable for the subsequent analysis. For each day we construct a spot rate curve that covers maturity dates from 1 to 10 years. For the actual pricing we set up a pricing engine from the open source quantitative finance library QuantLib. The coupon payment schedules are constructed according to each bonds' properties regarding payment frequency (annually, semi-annually) of the coupon as well as the actual coupon paid. We choose a settlement time of two days for each bond. With this parameterisation we obtain the theoretical yield for each bond for each day of the sample period.

We use these theoretical yields in combination with actually observed market yields to calculate the market wide illiquidity measure as described in the next section.

3.2 Noise as Illiquidity Measure

Besides some basic measures as autocorrelation, Principal Components Analysis and Regime-Switching models there exist two comprehensive measures to quantify systemic illiquidity. The first is proposed by Holló et al. (2012), who construct a composite indicator of systemic stress (CISS). The second is introduced by Hu et al. (2013), who measure systemic illiquidity as the price deviation from actual and theoretical bond yields (henceforth also referred to as "noise"). Our methodology to measure overall market illiquidity follows Hu et al. (2013) as it provides two crucial advantages. First, the measure can be easily determined for any arbitrary country, region, market or even bond class. In contrast, the CISS measure for bond markets is based on a government bond index and swap spread data. Second, the required data are implicitly available for each CCP due to their need of daily collateral price updates. Hence, there is no need to explicitly collect this data from a single CCP perspective and is easy to collect for regulatory authorities.

To identify a structural break from rational to irrational behavior with respect to overall market illiquidity, the systemic noise measure is defined as follows:

$$Noise_t = \sqrt{\frac{1}{N_t}\sum_{i=1}^{N_t}(y_{i,theo} - y_{i,market})^2} \qquad \forall t = 1, ..., T \tag{1}$$

where N_t is the number of fixed income bonds of day t, $y_{i,theo}$ is the theoretical yield and $y_{i,market}$ is the actual yield for bond i on day t. This measure proved to be a good indicator for liquidity crises as it provides 'new information about market liquidity beyond various existing liquidity measures' (Hu et al. (2013), p. 2343) . Furthermore, and even more important this measure, given its systemic nature, captures the overall market illiquidity. The term "noise" is derived from a fixed income context, where price deviations from a pricing model are often explained by noise. Therefore this noise measure can be understood as the aggregation of cross sectional pricing errors. Hu et al. (2013) also note that computing the noise with squared pricing errors relative to the duration yields similar results. The main result is therefore robust to both approaches.

3.3 Modification of the Noise Measure

Next, we propose a slight modification to the noise measure of Hu et al. (2013) to adjust it to our requirements. Originally, this measure is designed to measure systemic illiquidity and was first empirically evaluated with US Treasury bills, notes, and bonds which all contributed equally to the noise measure. We propose a generalization of the noise measure where the yield of the fixed income instruments is weighted by aggregated clearing member portfolio weights $\omega_{i,t}$.

$$Noise_t^{adj} = \sqrt{\sum_{i=1}^{N_t}\omega_{i,t} \times (y_{i,theo} - y_{i,market})^2} \qquad \forall t = 1, ..., T \tag{2}$$

and $\sum_{i=1}^{N_t}\omega_{i,t} = 1$.

The main advantage of this modification is that $Noise^{adj}$ better represents certain portfolios (e.g. aggregated CCP portfolios), where the weights can differ substantially from equal-weighting. Nonetheless, we report the noise measure for both position-weighted and equal-weighted.

3.4 Identifying Explosive Behavior

After the construction of a time series for overall market illiquidity, we seek to identify periods of explosive-, and bubble-like behavior. Homm and Breitung (2012) proposed several different test methodologies to test for an unknown change from a random walk to an explosive process.

They analyzed varying test procedures proposed by Bhargava (1986), Busetti and Taylor (2004), Kim (2000), Phillips et al. (2011), as well as a Chow type test with respect to their power properties.

For our own test procedure we impose the following requirements. First, the test should reliably detect single and multiple bubbles. Second, the same test procedure should be able to provide a date stamping method and provide a reliable estimator for the break date. Due to the fact that the test of Phillips et al. (2015) is much more robust against multiple, structural breaks than all other tests and provides a date stamping methodology by the same time, we choose their test statistic as the most suitable method. Therefore we follow Phillips et al. (2012) and use the recursive Generalized Sup Augmented Dickey-Fuller (GSADF) test procedure to identify the existence of multiple bubbles. The GSADF test procedure is a recursive and straightforward application of the supremum ADF (SADF) methodology, which is designed to provide additional power in identifying multiple breaks of exuberance and collapse. Next, we present the test procedures and outline the differences between the ADF, the SADF and the GSADF test.

As one can infer from Figure 1, the SADF test procedure itself is a recursive application of the simple ADF test (Dickey and Fuller, 1979) with an expanding window. Therefore, the GSADF test is a recursive application of the SADF test with varying starting points.

Figure 1: Overview of the test procedures

If the null hypothesis of the non-existence of any bubble is rejected, Phillips et al. (2015) propose to use the SADF backwardly (BSADF) as this procedure can be used for a date stamping procedure and consistently estimate time periods (origination and termination dates) of explosive behavior.

Formally, the empirical regression for each ADF test can be written as:

$$y_t = \mu + \delta y_{t-1} + \sum_{j=1}^{k} \phi_j \Delta y_{t-1} + \epsilon_t \qquad \epsilon_t \sim iid(0, \sigma^2) \tag{3}$$

where y_t is the time series which is tested for bubbles, μ is an intercept, δ is an autoregressive coefficient, ϕ_j for $j = 1, ..., k$ are the coefficients of the lagged first difference, Δ is the difference operator and ϵ_t are iid error terms. Equation 3 is used to test the null hypotheses of a unit root against the alternative of a stationary process:

$$\begin{aligned} H_0 &: \delta = 1 \\ H_1 &: \delta > 1. \end{aligned}$$

The test statistic of the simple ADF test is defined as

$$ADF = \frac{\hat{\delta}}{SE(\hat{\delta})}$$

where $\hat{\delta}$ is the standard OLS estimate of δ and SE representing standard errors.

Due to the fact that the SADF test applies the simple ADF test in a recursive manner on an increasing subsample of the whole data set, the test statistic is defined as the supremum of all ADF statistics. So for every observation with an index greater or equal than the minimum window size r_s a simple ADF test is applied recursively on a sample increasing observation by observation until the entire sample is used. We define the minimum number of observations analogously to Phillips et al. (2012):

$$r_s = \left\lfloor \left(0.01 + \frac{1.8}{\sqrt{T}}\right) \times T \right\rfloor \tag{4}$$

where $\lfloor \cdot \rfloor$ is the floor function and T represents the number of observations.

The SADF test statistic is then defined as the supremum of all simple ADF statistics:

$$SADF = \sup_h ADF_h \qquad h = r_s, r_s + 1, ..., T$$

The generalized sup ADF (GSADF) test is a generalization of the SADF test and is constructed by repeatedly implementing the SADF test procedure with varying first observation. The first iteration of the GSADF test is a SADF on the whole sample as introduced above and in Figure 1b). The second iteration applies a SADF on a subsample of $y_2, ..., y_T$. This procedure is repeated until the smallest number of observations r_s is reached.

The GSADF test statistic is defined as

$$GSADF = \sup_h SADF_h \qquad h = r_s, r_s + 1, ..., T - r_s$$

The limit distribution, the proofs and technical details of these test statistics can be found in Phillips et al. (2014). Due to the fact that the limit distribution of the SADF and GSADF has a nonstandard form, the critical values are obtained by Monte Carlo simulations.

After we explained the theoretical background, we continue with an empirical analysis, investigate the effects of haircuts and provide empirical evidence whether haircuts show a pro-cyclical pattern.

4 Empirical Analysis

4.1 Data

For our empirical analysis we use a long historical data set provided by a European central counterparty which includes stressed and stable market periods. The data set comprises all bond positions of each collateral portfolio for every clearing member. A single position is described by the variables date, ISIN, clearing member ID, quantity and price. The price is provided by the central counterparty and is the last observed market price. If there is no price to be observed, the price is estimated by the central counterparty. The observation time window ranges from November 2005 to February 2015. This time range comprises multiple distress periods for global (Financial crisis between 2007-2009) as well as European financial markets (Debt crisis between 2011-2012). This setup enables us to provide a clear picture of the developments in different phases of the business cycle. Securities provided as collateral can be pledged for two different purposes. Either as clearing fund contribution or margin collateral. Each position is flagged as clearing fund contribution or margin collateral. Cash positions are also flagged according to the purpose of usage (i.e. margin or default fund collateral). For non-cash positions daily haircuts are provided. In summary, for every security and clearing member the following information is provided on a daily basis: price, position size (i.e. total notional amount of the bond pledged by the clearing member), haircut, and currency.

For bond collateral, the provided data is enriched with information regarding maturity date, coupon frequency, coupon level and coupon type obtained from WM Data Service. These additional information are required for deriving theoretical prices and yields as previously explained in section 3.1. For our analysis we only consider EUR denominated bonds due to the fact that we have a yield curve derived from European Government Bonds denominated in Euro. We further restrict our data set to bonds with a fix coupon. Thereby we avoid errors stemming from more complex pricing approaches and are in line with the work of Hu et al. (2013).

To reduce estimation time and speed up our analysis we reduce observation frequency to weekly periods by considering Wednesdays only. The final data set comprises observed and theoretical yields as well as haircuts for over 480 Wednesdays between November 2005 and February 2015. The haircuts are updated on a daily basis by the central counterparty according to its risk management framework as is described next.

4.2 Dynamic Bond Haircuts

The bond haircut calculation methodology of the CCP is as follows[1]. Bond collateral haircuts follow a yield based approach. Haircuts are determined by full re-valuation (i.e. re-pricing) of each individual bond after its yield has been shocked applying the Yield Shift. The applied Yield Shift is comprised of market, credit and liquidity components. All haircuts are calculated to achieve a confidence level of 99.9% over a holding period of 5 days. Prudent minimum haircuts impose a floor on the dynamic component of the bond collateral haircut.

4.3 Descriptives

To clarify the characteristics of our data set we first show some basic descriptive statistics and then present the time series for the noise and the adjusted noise measure. To do so, we also briefly explain the determination of the weights $\omega_{i,t}$ for the adjusted noise measure (Equation 2).

[1]For reasons of confidentiality we do not present the exact formula to determine bond haircuts

According to Hu et al. (2013), we only consider bonds with a maturity between 1 and 10 years. While bonds with a maturity less than a year often suffer from demand and supply fluctuations and are therefore much noisier, the supply of bonds with maturity longer than 10 years may not be stable (and there were less observations in our data set). In addition to removing bonds with an unreliable maturity we remove bonds with unrealistic prices and negative yields. We calculate both noise measures for each Wednesday with at least 100 bonds. On average we consider 400 bonds daily spiking to 800 bonds in turbulent times. The high volatility in the number of bonds within the clearing member portfolios can be traced back to different reasons. As an obvious cause, margin requirements increase in turbulent times and clearing members pledge more bonds to meet the margin requirements. An additional reason are CCP-services, e.g. the optimization of clearing member collateral usage. The number of bonds moved into and extracted from collateral portfolios is significantly higher for members that are customers of these services. However, this does not influence our measure in any way as it is based on a per bond analysis.

By comparing the issuing countries of all bonds it is not surprising that German bonds are the most used bonds in our data set, representing approximately 52% off all bonds. Other frequently used issuing countries are France (11%), Spain (6%), Italy (4%), Austria (3%) and United Kingdom (3%).

In the following analysis we differentiate between four different time series. The normal noise measure (Figure 2a), where the yield is derived from theoretical prices and actual market prices, the noise measure derived from theoretical prices and haircut adjusted market prices (Figure 2b) and these two time series calculated with the adjusted noise measure (Figure 3).

While the normal noise measure (Equation 1) considers the whole data set of bonds, with all bonds equally weighted, our newly introduced adjusted noise measure (Equation 2) takes the notional position of each clearing member into account and weights the noise by the aggregated notional position of all clearing members. This setup provides insights with respect to the relevance of the overall collateral diversification. The weights for each day and for each bond are determined with the following formula:

$$\omega_{i,t} = \frac{\sum_{j=1}^{CM_t} NP_{i,j,t}}{\sum_{i=1}^{N_t} \sum_{j=1}^{CM_t} NP_{i,j,t}} \qquad \forall t = 1, ..., T; i = 1, ...N_t.$$

where $NP_{i,j,t}$ represents the notional position of bond i on day t for the clearing member (CM) j.

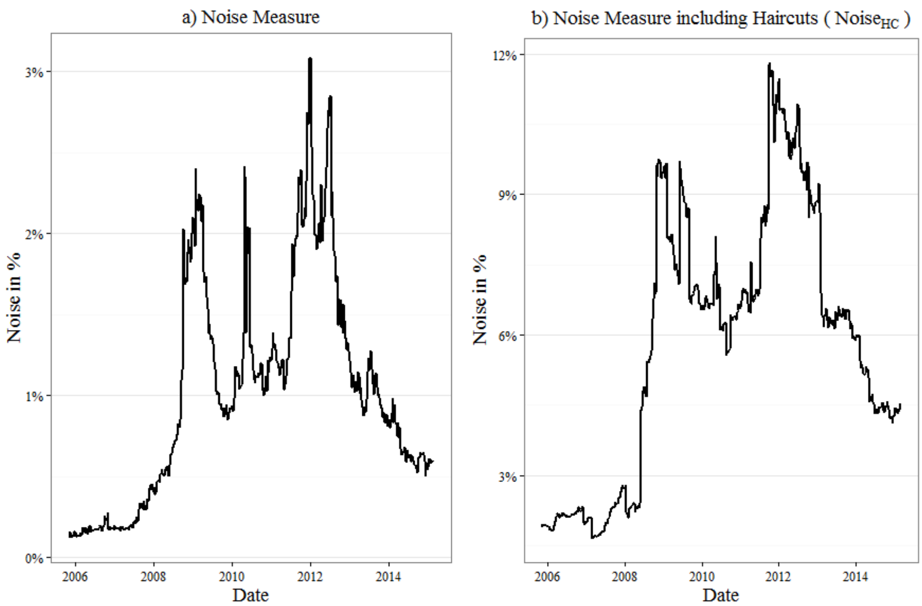

Figure 2: *Noise*: All bonds equally weighted

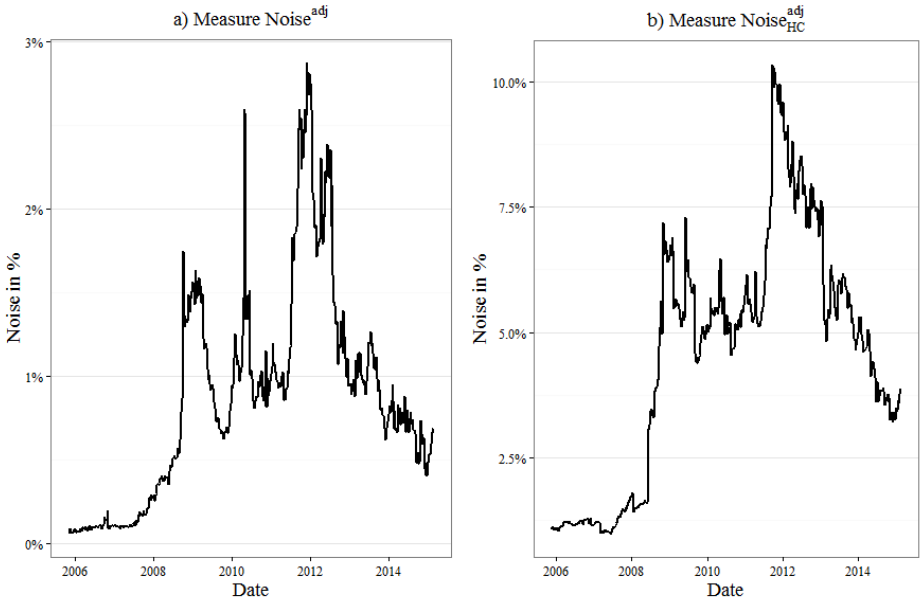

Figure 3: $Noise^{adj}$: Bonds weighted by notional amount pledged by all clearing members

Descriptive Statistics				
Statistic	$Noise$	$Noise_{HC}$	$Noise^{adj}$	$Noise_{HC}^{adj}$
Mean	1.03%	5.81%	0.88%	4.53%
Median	0.96%	6.32%	0.85%	5.07%
Standard Deviation	0.0069	0.0282	0.0065	0.0245

Table 3: Descriptive statistics for the $Noise$ measures

As one can infer from table 3 and figures 2 and 3, the noise measure without considering a haircut fluctuates around 10 and 75 bps in normal times with a standard deviation of 0.0069 for the whole time series. In turbulent times (from 2008 to 2013), the noise can spike up to 300 bps. By definition, the time-series mean and median for the noise measures considering a haircut (HC) are much higher. Periods of high illiquidity, like 2008-2009 and 2011-2012 coincide with turbulent financial distress within Europe. While the normal noise measure can easily be interpreted as an indicator for illiquidity for Europe, the noise measures considering haircuts are more of a synthetic illiquidity measure indicating the theoretical illiquidty for considered prices with applied haircuts. In addition, the adjusted measure seems to slightly soften the fluctuations and smooth the whole time series as the spikes seem to be damped. This might stem from preferences for more liquid bonds, which is in line with common stylized facts about flight to liquidity (Brunnermeier and Pedersen, 2008).

The spike around 2010 can be traced back to the Greek government-debt crisis. Due to the fact that Greek bonds only were eligible as collateral until June 2010 the volatility caused by Greece bonds vanishes after that date. The smaller peak in the adjusted noise measure can be explained by a relatively low notional position of all clearing members in Greek bonds during that respective time. Therefore, bonds exhibiting high pricing errors, i.e. high levels of noise, are lower weighted in collateral portfolios.

4.4 Testing for Multiple Bubbles and Date Stamping

To analyze whether haircuts show pro-cyclical behavior we start by applying the GSADF and SADF test (in line with Phillips et al. (2012)) and test for the existence of multiple breaks. Subsequently, if the first tests indicate multiple periods of explosive behavior we identify the origination and termination dates of the corresponding periods.

For the following test we consider the time series of the standard noise measure (Equation 1) and the adjusted noise measure (Equation 2). The table below (Table 4) reports the four test statistics and the critical values obtained from Monte Carlo simulations with 2000 replications of 480 observations. According to Equation 4, the smallest window contains $(0.01 + 1.8/\sqrt{T}) \times T \approx 44$ observations. From Table 4, the GSADF test statistics are 8.4 and 8.84 for the time series considering no haircuts and 4.21 as well as 4.4 for the noise measures considering a haircut. All test statistics exceed their 1% right-tail critical values of 2.73, giving strong empirical evidence of explosive sub-periods, which is once more confirmed by similar results of the SADF test. We conclude from both tests that there is evidence of multiple bubbles in both noise measures.

GSADF and SADF Test

This table reports GSADF and SADF test statistics for the null hypothesis of a unit root against the alternative of an explosive root, where $r_s = 44$. The series are the different (adjusted) noise measures with and without haircuts. The critical values for the test statistics are obtained by Monte Carlo simulation with 2,000 replications.

Test	Noise Measure	Test Statistic	Critical Value		
			90%	95%	99%
GSADF	$Noise$	8.40	1.99	2.25	2.73
	$Noise_{HC}$	4.21			
	$Noise^{adj}$	8.84			
	$Noise^{adj}_{HC}$	4.40			
SADF	$Noise$	8.32	1.16	1.48	2.15
	$Noise_{HC}$	4.12			
	$Noise^{adj}$	8.79			
	$Noise^{adj}_{HC}$	4.31			

Table 4: Test statistics for the $Noise$ measures

After the identification of multiple bubbles in all time series, we use the BASDF test statistic of Phillips et al. (2015) to identify the origination and termination dates of explosive periods.

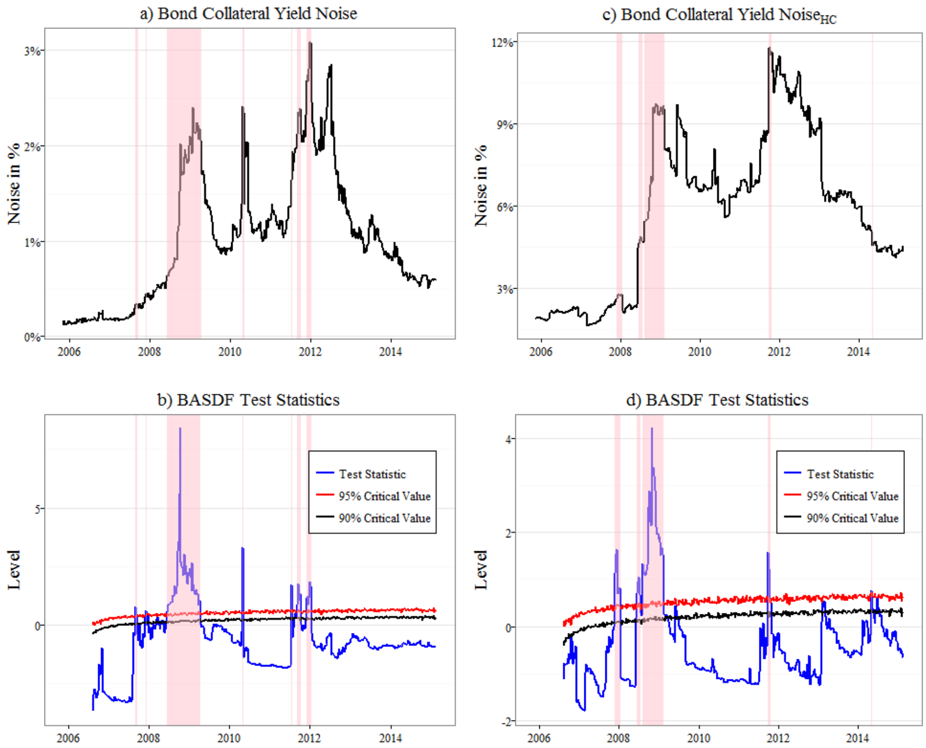

Figure 4: Detected bubble periods via the $Noise$ measure

Figure 4a) and Figure 4c) represents the noise and the haircut considering noise measure. The blue lines of Figure 4b) and Figure 4d) are the corresponding BSADF test statistics as well as the 95% (red line) respectively 90% (black line) critical values, which are obtained by Monte Carlo simulations. To identify explosive periods, we red colored these periods where the BASDF test statistics exceed their 95% critical values. From Figure 4, the identified periods of irrational and explosive behavior include the global financial crisis where the first signs of a crisis are identified in August and December 2007, the outbreak of the financial crisis in Europe is identified in June 2008 lasting until April 2009. As already mentioned, the second spike is related to the periods of financial turmoil in Greece and is identified in April 2010, very timely after the formal request of a first bailout package for Greece. The third set of periods with explosive behavior is identified in July 2011 and is obviously related to the ongoing financial distress in many European countries. The sharp decline in January 2012 (see Figure 4a) after the last identified bubble) is a likely consequence of the start of the ECB's Securities Market Program liquidity infusion into the banking system.

The bubble periods identified with $Noise_{HC}$ are very similar to the bubble periods described above but they differ in length and with respect to the starting point. The length is considerably shorter, we only identify 43 weeks of irrational illiquidity instead of 62 in the normal measure.

The conclusions from Figure 5 which represents the illiquidty measured for a single CCP are very similar. The identified periods of explosive behavior are roughly the same but they differ imperceptibly in length.

Due to the fact that the noise measure considering haircuts always display less bubble periods than the normal noise measure (43 and 49 instead of 62 and 69) and we are not able to observe a foreshadowing or amplifying behavior of $Noise_{HC}$ or $Noise^{adj}_{HC}$, we conclude that the design of past and present haircuts does not co-move or even exacerbate market-wide illiquidity. Furthermore, we observe that illiquidity measured for noise with applied haircuts is much smoother and is not as explosive as it is for the normal illiquidity measure.

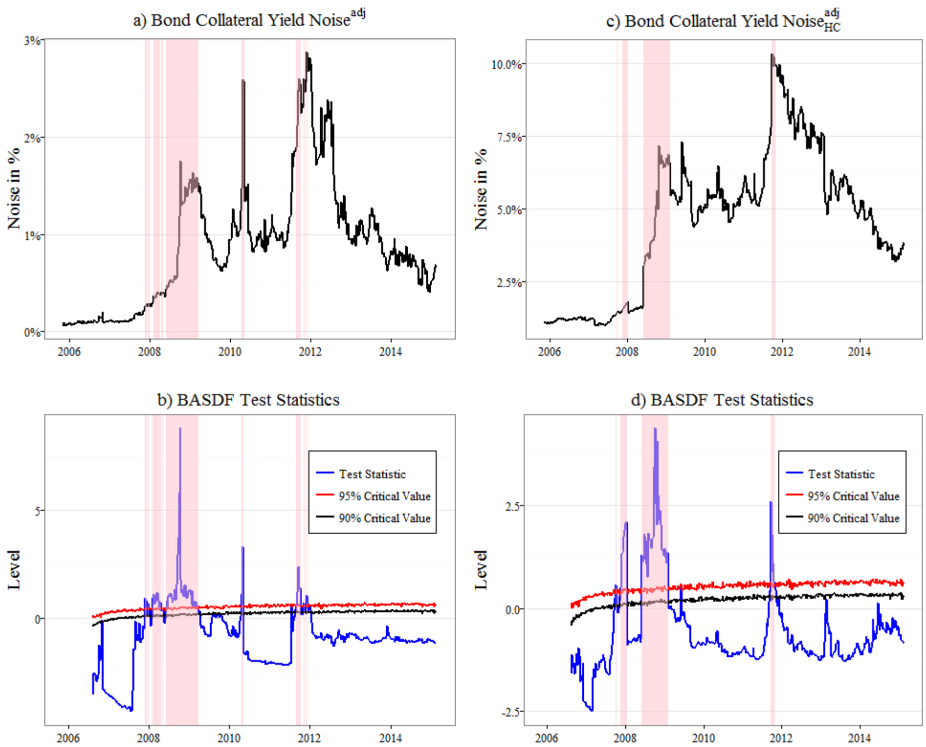

Figure 5: Detected bubble periods via the $Noise^{adj}$ measure

Number of Explosive Weeks				
	$Noise$	$Noise_{HC}$	$Noise^{adj}$	$Noise^{adj}_{HC}$
# Explosive Weeks	62 (13%)	43 (9%)	69 (14%)	49 (10%)
Union	70 (15%)		76 (16%)	

Table 5: Statistics of explosive weeks

Due to the fact that the GSADF test only indicates the existence of explosiveness, but does not provide insights regarding the magnitude of this behavior we introduce $Ratio = \frac{Noise_{HC}}{Noise}$ and $Ratio^{adj} = \frac{Noise^{adj}_{HC}}{Noise^{adj}}$. By definition and due to the fact that at least a minimum haircut is applied, *Ratio* and $Ratio^{adj}$ are always greater 1. The underlying intuition is the following: If haircut levels are co-moving with increasing volatility in bond markets, this relationship should lead to a higher deviation from the theoretical price. For example, if risk premia rise, i.e. bond prices fall, an applied haircut would lower the price even further, hence lead to higher levels of noise. Also, haircuts are, by design, lower for high quality bonds and higher for low quality bonds. Thus, even behavior like flight to liquidity or flight to quality should not dilute this relationship. Therefore, if the ratio shows irrational behavior and explosive periods we can conclude that the design of the haircuts features a pro-cyclical effect. Therefore we test for explosive behavior:

GSADF Test

This table reports GSADF test statistic for the null hypothesis of a unit root against the alternative of an explosive root, where $r_s = 44$. The series are the ratio of the different (adjusted) noise measures with and without haircuts. The critical values for the test statistics are obtained by Monte Carlo simulation with 2,000 replications.

	GSADF Test Statistic	90% Critical Value
$Ratio$	1.09	1.99
$Ratio^{adj}$	0.87	

Table 6: Statistics for GSADF test

Both test statistics of the GSADF test indicate that there are no bubbles in the ratio of $\frac{Noise_{HC}}{Noise}$ and $\frac{Noise^{adj}_{HC}}{Noise^{adj}}$. Considering our line of arguments above, these results indicate that there is no pro-cyclical behavior of haircuts. What we observe in Figure 6 is the convergence of both time series during the periods prior to the global financial crisis in 2008. We assume that the "buffer" induced by the minimum haircuts, i.e. the haircut induced pricing error, is consumed during this period. We can also see the buffer slowly building up during more tranquil times in 2013 and 2014. The reason for the slow build up of the buffer could stem from comparably higher levels of cash pledged as collateral (around 50% of overall collateral after 2012 compared to 25% in pre-2008).

However, the non-existence of irrational deviation between $Noise_{HC}$ and $Noise$ respectively $Noise_{HC}^{adj}$ and $Noise^{adj}$ allows no final conclusion regarding pro-cyclical behavior. The possibility of a pro-cyclical effect but in a "non-explosive manner" is yet to be tested. To investigate this case, we divide each ratio into explosive and non explosive periods according to the section above. This means, whenever the statistical test on any of the two noise measures indicates a bubble period we label the corresponding period for the ratio as an explosive behavior period. Put differently, we define an explosive period for *Ratio* if either the time series of $Noise$ or of $Noise_{HC}$ indicates bubbling behavior. In technical terms, we take the union of both time series' bubble periods.

Figure 6: Periods of bubble-like behavior of *Ratio* and $Ratio^{adj}$

Next, we test for significant differences between the ratio in explosive and normal times.

A higher ratio in bubble times compared to normal times would indicate procyclicality as the illiquidity measured with haircuts would be even higher (in relative terms) than illiquidity measured without considering the haircut. Recall that we divide $Noise_HC$ by $Noise$ where the former is based on the latter and hence should at least considerably co-move, i.e. making changes in the ratio attributable to the haircuts. A simple comparison of explosive periods and periods of no indication for explosive behavior points out that both ratios in turbulent times are obviously lower, highlighting once more that there is no evidence of procyclicality. In addition, we run a simple t-test and a Shapiro-Wilk test to detect significant differences in the mean and median for the ratio within a bubble period and the ratio in normal times. The results are reported in Table 7.

Comparison of Sub-Periods			
(No)Bubble	Metric	*Ratio*	$Ratio^{adj}$
	Mean	5.19	4.83
Bubble	Median	5.07	4.33
	Std. Deviation	1.31	1.33
	Mean	7.29	7.00
No Bubble	Median	6.64	6.05
	Std. deviation	2.65	2.94

Table 7: Comparison of bubble and no bubble periods

Both tests reveal that the assumption of equal mean and medians can be rejected with a significance level way beyond 99% (p-values not reported). This statement even holds if we exclude observations until the first bubble occurs which could distort the results due to rather low levels during the period prior to the crisis. Moreover, the volatility as a measure of uncertainty is considerably lower in bubble periods compared to periods where no bubbles are detected.

4.5 Macroprudential Add-On: Deriving Haircut Discounts

In the following, as a final step, we introduce a method to derive haircut discounts in times of irrational (funding) liquidity distress. These haircut discounts are designed to provide relief of distrust induced systemic illiquidity in periods of explosive behavior. These periods are known to be driven by extreme distrust among financial market participants. The reasoning behind our approach is to interrupt the potentially triggered liquidity spiral of tightening funding conditions if the period of systemic illiquidity tends to stretch over time instead of being a temporary spike of distrust. Put differently, the discount increases with the time the systemic illiquidity is observed.

The proposed haircut add-ons are computed for each bubble separately by the following formula:

$$HC_{dscnt,i} = \int_{s}^{i} (Noise_x - Noise_s)dx \tag{5}$$

where $s = \min_i \{i \mid CriticalValue_i(95\%) < BSADF_i(Noise)\}$ represents the start of each bubble. The discount for day i can be interpreted as the area under the $Noise$ curve from the start of the bubble until day i.

To illustrate this method, we exemplarily visualize the computation of the haircut discount for an arbitrary day i in Figure 7.

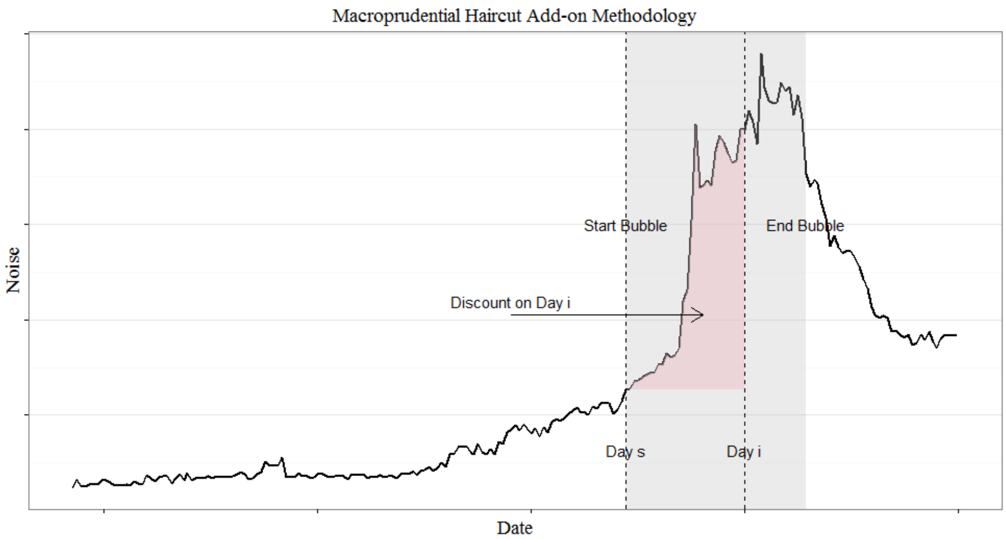

Figure 7: Illustration of the computation method for haircut discounts

By strictly applying Formula 5, the end of a bubble would result immediately in a plunge of discounts to zero. To avoid this unnecessary and additional volatility resulting from an abrupt termination of granted discounts, we suggest to depreciate the discount linearly over the length of the previous bubble period. This means, whenever the statistical test indicates the end of the bubble, which lasted let's say z weeks, we depreciate the computed discount linearly over the next z weeks. In the case that a depreciation period overlaps with the start of a new bubble period we suggest to take the maximum of both values for reasons of conservation. That means, if the actual noise levels rise above the level of current depreciation from the previous bubble period, the actual noise is taken and the building up area under the curve of actual haircut noise is taken as a discount.

Figure 8: Impact of the macroprudential haircut discounts

What is observable in Figure 8 is that the proposed methodology prevents lasting periods of irrationality but does not intervene if the systemic illiquidity is of short temporary nature and if it is dissolved by market participants themselves. During the period of the longer lasting financial distress phase beginning in 2008, the add-on becomes increasingly active and smoothes the irrational component of the system wide illiquidity. We argue that this is a highly desirable feature since market interventions should be reduced to the bare minimum necessary and be based on a data driven approach instead of discretionary or even political decision making processes.

Although the initially rising haircuts are reasonable to take rising default probabilities into account, the system wide and explosive development of illiquidity is not and is to some extent driven by panic and unreasonable distrust. The scenario that the majority of European government and corporate bonds is simultaneously defaulting in a short period of time is highly unlikely from a fundamental perspective. The in-crisis situation of irrational illiquidity is at best contributing to the likelihood of that scenario or a less severe sub-scenario. Hence, we argue that smoothing out the irrational component by a quantitative and hence automatable approach is the most suitable option.

A counter argument is that participants could enter into new positions with the freed-up liquidity. However, in such a period distress and distrust is already on a comparatively high level. Taking on new positions with highly distrusted counterparties on a system wide level is therefore highly unlikely. Additionally, the mechanism only comes into force if illiquidity becomes irrational on a systemic level and is lasting for some time. Hence, it is impossible for single institutions or a group of institutions to deliberately trigger the mechanism.

In the second distressed period, we observe that the peak of systemic illiquidity is of short nature and after the peak being reached the decline is forced almost immediately. The add-on becomes active for a short period after the actual peaks but is vanishing directly after the beginning of market driven reduction of irrational illiquidity. This again demonstrates the desirable conservative nature of the proposed add-on with respect to the extent and period of intervention.

Overall, the proposed macroprudential haircut add-on mechanism acts counter-cyclical at the peak of financial distress, smoothes out irrational illiquidity that could result in liquidity spirals, is triggered by a relatively simple quantitative mechanism and is quite conservative regarding magnitude and time period of market intervention.

To sum up the empirical analysis, we first investigated two different noise measures over a long historical period and observed multiple structural breaks to explosive behavior coinciding turbulent financial distress in Europe. Furthermore, we observe that noise measured with haircuts taken into account is much smoother and less explosive compared to the no-haircut noise. Supported by various statistical tests, the main finding is that we were not able to detect a pro-cyclical effect induced by applied haircuts. Hence, we are able to reject the hypotheses of pro-cyclical haircuts and conclude that haircuts are not exacerbating market-wide illiquidity during times of distress. Nevertheless, we introduced a concrete method for a macroprudential haircut add-on, which is able to smoothes irrational and system wide illiquidity in a desirable amount.

5 Discussion

The results of our empirical study clearly confirm Brunnermeier and Pedersen's (2008) prediction of sudden jumps in illiquidity. This is in line with previous literature on market-wide liquidity, i.e., stylized facts on commonality in liquidity and flight to quality (Chordia et al., 2000). Irrational illiquidity is mostly a trust issue in the financial network and hence a problem to be addressed from a macroprudential perspective. As stated by CGFS (2009), a macroprudential perspective is always needed regarding modifications of haircuts or margins. We follow the argument that the effect of building a buffer during calm market phases via minimum haircuts enables the market to absorb parts of this additional liquidity during the initial phase of a distressed market period. However, we argue that macroprudential intervention should be based on a quantitative approach instead of discretionary decision making. The design of the proposed macroprudential haircut add-on fulfills all of the specified requirements as it is a) considering a liquidity component from a macroprudential perspective, b) limiting pro-cyclical effects when needed the most and finally c) the transparent and free-of-bias component in form of a quantitative trigger. To highlight the characteristics of the proposed haircut add-on, we will discuss its properties in more detail in this section.

The discussion will be set up against the backdrop of broader literature on contagion channels of systemic risk. A comprehensive summary is provided by Clerc et al. (2016) on which we rely subsequently and refer to for an in-depth discussion of prices as contagion channels for systemic risk. In particular, Clerc et al. (2016) discuss indirect contagion via market prices or information spillovers. They introduce two different haircut and margin restrictions and analyze their effects under the premise of either no foresight, partial or full foresight of shock induced haircut increases as well as their timing. In contrast, our macroprudential trigger is neither able nor in need to forecast a point in time of shock events which result in haircut jumps or to forecast future haircut levels. Despite the less demanding prerequisites, our proposed macroprudential haircut discount results in a timely and adequate reduction of systemic illiquidity by adjusting haircut levels at a systemic scope. Hence, it links the systemic risk perspective with the procyclical tendencies of haircuts. Against the backdrop of these basic properties, we discuss the efficiency with regard to different reactions of single participants and the aggregate financial market respectively.

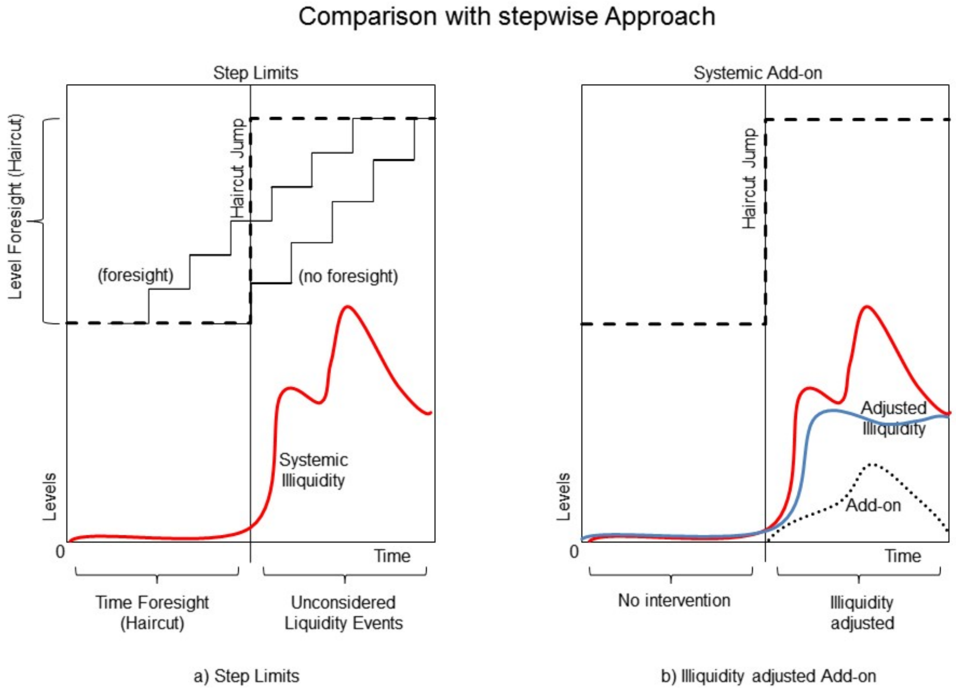

Figure 9: Comparison of our macroprudential add-on with step limits

Figure 9 a) depicts a market shock resulting in increased haircut requirements (coarsely dashed lines in Figure 9 a) and b)). As argued by Clerc et al. (2016), this sudden increase should be damped by stepwise increments or time-varying minimum haircuts. We argue that market-wide shocks tend to exaggerate actual conditions and the irrational part of a shock should not be continuously reflected in haircuts. If this is the case, participants' liquidity pressure would be driven by both market wide illiquidity on the one hand, which coincides with shock events, as well as reduced value of collateral portfolios due to haircut jumps on the other hand. Given these considerations, our macroprudential haircut add-on is designed in a way that it lowers the overall haircut level posterior to a shock event according to the irrational component of illiquidity in the market (compare Figure 9 b)). This way, it prevents conditions for indirect contagion which could result in systemic illiquidity spirals. Consequently, clearing members do not suffer from high haircuts (jumps) and benefit from decreased liquidity constraints during illiquid market phases. These properties are achieved without forecasting or discretionary decision making.

It is worth noting, that the systemic illiquidity of collateral markets is hardly to justify by an increase in default probability of every issuer at the same time and in a sudden jump. Only the irrational illiquidity itself introduces an increased overall default probability and can hence be considered self-reinforcing or self-justifying. By our approach we break this aggregate behavior inherent spiraling of systemic market illiquidity.

Figure 10 shows different scenarios of possible market and clearing member reactions to an add-on trigger event and its accompanying haircut discounts as proposed in this work.

If the market ignores the triggered haircut add-on completely and the systemic illiquidity does not only persist but actually increases, the discount will rise with increasing speed until either the market reacts to the continuously lowered haircut requirements or the irrational behavior vanishes (see Figure 10a). Either way, the collateral cots will decrease accelerating according to the irrationality component.

By assuming that the market will only partially react to a triggered haircut add-on (see Figure 10 b)), we assume that the level of irrational exaggeration persists on the same level due to actual shifts in conditions as participants figure out over time. This scenario results in continuously decreasing collateral cots until the period of a bubble ended. Subsequent to the bubble period, the add-on is slowly reversed in the phasing out period. Hence, participants are granted time to adjust to the new level. This way, the add-on is able to dampen the irrational component but is not able to extinguish irrational behavior that preceedes reaching a new, higher but stable plateau.

If the market and the clearing member immediately react to the haircut add-on (see Figure 10 c)) or the irrationality holds for a short period of time, the irrational part of the systemic illiquidity vanishes timely after the identification of the bubble and the add-on succeeds in reverting irrational behavior.

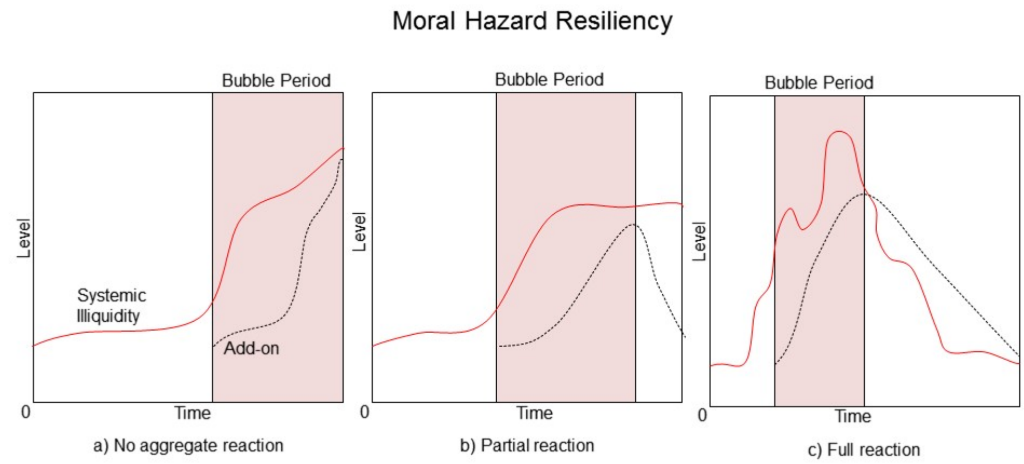

Figure 10: Different (stylized) market reactions to applied haircut discounts

A critical issue emphasized by Clerc et al. (2016) is the moral hazard resulting from central banks to be lender of last resort (LOLR). Considering the discussion above, we argue that the moral hazard issue is reduced or circumvented by relying on the proposed add-on. The trigger mechanism can be based on the aggregate market perspective, i.e., the authority gathers data from multiple national CCPs clearing member collateral portfolios. Hence, the trigger only reacts to systemic events which cannot be induced by single, not even systemic important, financial institutions. Additionally, the need for liquidity provided by an LOLR is reduced due to canceling out of the irrational part of systemic illiquidity.

However, the actual effectiveness of our proposed haircut add-on depends on a careful calibration and implementation. The calibration and the implementation of the add-on have to ensure a smooth and well-balanced risk transfer between the CCPs and the clearing members and should limit regulatory arbitrage.

With our analysis we contribute to theory in multiple ways. Our contribution to the existing literature is threefold. First, we generalize a common noise measure to quantify systemic illiquidity and propose a modification to adjust it to specific countries, regions or sets of exchanges. Second, we reject the assumption of pro-cyclical behavior of haircuts that are designed according to current recommendations. Third, we introduce a quantitative and non-discretionary haircut add-on methodology to eliminate additional and irrational systemic illiquidity in periods of financial distress.

The practical contribution of our work is manifold. First, the profound empirical analysis and the obtained results about the actual effect of haircuts contribute to the ongoing discussing about the macroprudential design of haircuts. Second, we propose a macroprudential haircut add-on based on a quantitative trigger that is immediately applicable for any authority. The underlying approach is also capable of monitoring systemic distress (i.e. the start of an irrational bubble). The approach, in combination with minimum haircuts, also fulfills the requirement of CGFS (2010) - among others - who recommend to design haircuts more conservative and stable across the cycle. The effects of numerical haircut floors are described our analysis of buffers that are built up during calm market phases are consumed on the way towards distress periods. Third, the suitability of the proposed procedure is emphasized by the following properties: First, no discretionary decision making is necessary. Second, our proposed measure is easy to calculate and interpret. Fourth and last, all of our applied measures seem to capture irrational phases only as the proposed test methodology indicates no type II errors.

There are, of course, some limitations worth to be discussed or mentioned. One might argue that our approach is only considering the bust phase of the cycle. However, the empirical analysis indicates that minimum haircuts are indeed gradually consumed during the build up of a bust phase. Hence, our add-on methodology is complementary in design to minimum haircuts who might be able to control excessive leverage during tranquil phases of the business cycle.

In our empirical analysis we only focus on securities that have been pledged at any point in time between 2005 and 2015 by any member of a single CCP. Due to the fact that we want to analyze collateral haircuts from a macroprudential perspective this might be considered a limitation of our paper. The definition of the setup that provides a systemic perspective is, however, hard to come up with. That said, we argue that the data setup does not undermine the validity and relevance of the obtained results but might only lead to slight differences regarding the absolute level of noise or the length of bubbles. It holds that the larger the set of securities underlying the procedure the better the macroprudential perspective. Nonetheless, the studied CCP provides a comparatively large portfolio of eligible collateral to choose collateral from which highlights the broad scope of our analyses.

Finally, the selection of the noise measure should be outlined in more detail. Hence, we aim to compare in more detail the chosen noise measure against other systemic stress indicators like, e.g., the CISS indicator proposed by Holló et al. (2012). Based on preliminary comparisons, the CISS indicator showed quite similar behavior as the noise measure. The underlying time series representing systemic illiquidity does, however, not influence our general approach.

6 Conclusion

In this paper, the question whether collateral haircuts show a pro-cyclical pattern is investigated and a macroprudential hairuct add-on to mitigate irrational illiquidity is proposed. The analysis is based on a unique data set of collateral portfolios provided by a European central counterparty. In particular, we use a noise measure of collateral bond yields as an indicator for systemic, market wide illiquidity and analyse the relationship between illiquidity and collateral haircuts. We can reject the hypotheses that collateral haircuts and collateral price volatility are positively correlated by comparing the noise measure for yields with and without haircuts applied. We do not observe any empirical evidence for a pro-cyclical effect of CCP haircuts which are designed in line with recently suggested requirements and best practices. Indicative findings point to the existence of the often discussed buffer effect of minimum through-the-cycle haircuts.

As outlined previously, for our analysis we apply a measure to identify the start and end points of periods of irrational systemic illiquidity. In addition to doing exactly that, this indicator serves as a quantitative trigger for a macroprudential haircut add-on. The proposed haircut add-on shows desirable features to mitigate stretching periods of irrational liquidity constraints during periods of financial distress.

For the next stage of our work, we plan to extend our data set to all eligible bonds of a CCP and/or the eligible portfolio of collateral securities of the European Central Bank in order to achieve a broader, more systemic perspective.

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