Beyond Policy Rates: Macroeconomic Effects of Lender-of-Last-Resort Shocks*

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Abstract

This paper shows that lender-of-last-resort (LOLR) shocks trigger significant and persistent macroeconomic effects. We introduce a novel identification strategy that leverages the informational content of the "haircut gap" - the difference between private market and central bank haircuts on eligible collateral - combined with narrative sign restrictions within a structural VAR framework. We show that favorable LOLR shocks improve credit market conditions, boost economic activity, raise inflation moderately, and reduce systemic financial risk, highlighting collateral policy as a powerful and distinct central banking tool.

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Non-Technical Summary

Central banks pursue multiple objectives using a range of policy instruments. While conventional monetary policy operates primarily through short-term interest rates to stabilize inflation and economic activity, central banks also act as lenders of last resort (LOLR), providing liquidity to banks against collateral to prevent financial stress from escalating into systemic crises.

The collapse of Silicon Valley Bank (SVB) in March 2023 brought renewed attention to the macroeconomic role of lender-of-last-resort (LOLR) policy. The Federal Reserve's response allowed banks to borrow against eligible securities at book rather than market value, effectively providing a sizable collateral-based subsidy. This episode highlights how the wedge between private market and central bank haircuts shapes the liquidity available to distressed institutions.

This paper analyzes the macroeconomic effects of LOLR shocks using a novel identification strategy that exploits the informational content of the "haircut gap." We focus on collateral policy, a core component of the ECB's liquidity provision framework. Our analysis exploits variation in the haircut gap—the difference between haircuts applied by the ECB on its collateralized refinancing operations and those imposed by private repo markets on the same collateral—which captures the implicit funding advantage banks receive when borrowing from the central bank. Using detailed security-level data and a novel identification strategy that combines this information with narrative restrictions in a structural VAR framework, we isolate exogenous shocks to LOLR policy.

We find that favorable LOLR shocks—corresponding to more accommodative collateral haircuts—have economically meaningful and persistent effects on the economy. In particular, they lead to lower unemployment and higher inflation over the medium term, indicating a delayed but durable expansionary impact on real activity. These effects operate primarily through the banking sector. LOLR shocks improve credit market conditions by lowering lending rates and increasing loan volumes to both firms and households, with no evidence of credit reallocation across borrower types.

Beyond real activity, LOLR policy plays an important role for financial variables. We show that favorable LOLR shocks significantly reduce banks' funding costs, as reflected in a persistent compression of bank bond spreads. At the same time, systemic financial risk—measured by the expected capital shortfall of the financial sector—declines sharply following an LOLR shock and remains below baseline for several years. This pattern is

consistent with the traditional view of the lender of last resort as a stabilizing force during periods of financial stress. Importantly, these benefits do not come at the cost of impaired money-market functioning: unlike conventional monetary policy shocks, LOLR shocks have little effect on dispersion in money-market rates.

A key contribution of the paper is to show that LOLR policy is empirically and conceptually distinct from conventional monetary policy. Although the two instruments can have effects of similar magnitude on macroeconomic and financial variables, they differ markedly in their transmission mechanisms and timing. Monetary policy shocks affect real activity and financial markets rapidly and steepen the yield curve, while LOLR shocks operate with longer lags, flatten the yield curve, and primarily influence bank funding conditions and systemic risk. These differences reflect the distinct objectives of the two tools: price stability for monetary policy and financial stability for LOLR interventions.

Overall, our findings establish central bank collateral policy as an independent and powerful macro-financial policy instrument. They highlight the importance of jointly modeling monetary policy and LOLR interventions when assessing central bank actions and suggest that, in principle, central banks can rely on multiple policy levers—interest rates and collateral frameworks—to stabilize the economy. The optimal joint design of these instruments remains an important question for future research

Introduction

Central banks pursue multiple objectives through distinct, yet interconnected, policy functions. Monetary policy is typically conducted through the setting of short-term interest rates to stabilize inflation and aggregate demand. At the same time, central banks act as lenders of last resort (LOLR), providing liquidity to financial institutions to prevent temporary funding shortages from propagating into systemic crises.[1]

A defining feature of LOLR policy is its reliance on collateralized lending, through which central banks shape banks' funding capacity and balance-sheet constraints by adjusting collateral valuations. The collapse of Silicon Valley Bank (SVB) in March 2023 brought this mechanism to the forefront of the policy debate. In response, the Federal Reserve allowed eligible institutions to borrow against collateral valued at book rather than market prices, effectively eliminating the market-implied haircut on a broad class of securities. This intervention amounted to a substantial haircut subsidy and materially expanded the liquidity available to distressed institutions. The SVB episode thus highlighted the macroeconomic importance of collateral policy and the informational content embedded in the *LOLR haircut gap* — the wedge between private market and central bank haircuts.[2]

Despite the central role of liquidity provision in modern central banking, empirical evidence on the aggregate effects of LOLR policy remains scarce. Existing studies have largely focused either on bank- and security-level outcomes (e.g. Drechsler et al., 2016; Jasova et al., 2023; Acharya et al., 2019) or on the aggregate effects of conventional and unconventional monetary policy shocks (e.g. Christiano et al., 1996, 1999; Gertler and Karadi, 2015). As a result, it remains unclear whether, and through which mechanisms, LOLR interventions translate into real activity and prices. This paper addresses this gap by providing new evidence on the macroeconomic and financial consequences of shocks to LOLR policy, thereby establishing central bank collateral frameworks as an independent and economically meaningful policy instrument.

A key reason for this gap is methodological: core LOLR policy variables, such as collateral haircuts and banks' collateral pledging decisions, are inherently endogenous, operate at a high level of granularity (e.g., security- or bank-level), and typically vary during periods of

[1] Refinancing operations—implemented historically through competitive auctions or open-market operations—remain a foundational central banking instrument.

[2] Such implicit gaps are typically justified by the presence of market failures (Freixas and Rochet, 1998; Rochet and Vives, 2004), including fire-sale dynamics, funding market freezes, and coordination failures that impair the efficient provision of liquidity during periods of stress.

acute financial stress. These features complicate aggregation and make it difficult to isolate exogenous variation. As a result, standard VAR approaches struggle to identify credible shocks to collateral policy without additional identifying assumptions.

This paper overcomes these challenges through two main contributions. First, we introduce a novel identification strategy that combines granular information on collateral usage and haircuts with narrative restrictions, allowing us to recover exogenous movements in the aggregate haircut gap. Our specific approach involves combining the traditional "monetary" Bayesian vector autoregression (BVAR) (e.g. Bernanke and Blinder, 1992; Christians et al., 1996) with the use of an "information variable" built using granular information on the haircut gap. Second, using this identification scheme, we analyze the joint response of a variety of macroeconomic and financial variables and shed light on the significant and persistent effects of LOLR shocks on the aggregate economy. Third, we contrast LOLR shocks with conventional monetary policy shocks and compare their aggregate implications. A key finding is that the yield curve slope responds with opposite signs to the two shocks, offering a sharp empirical distinction between them. Bank bond spreads and systemic risk also exhibit distinct timing patterns in their responses to the two shocks.

We use micro-level data on the haircuts applied to the collateral pledged by banks in repo transactions both with the ECB and in the private market to construct the LOLR haircut gap as in (see Drechsler et al., 2016; Jasova et al., 2023). We exploit the information content of the variation in the haircut gap over time to identify the macroeconomic impact of LOLR shocks using a combination of sign and narrative restrictions (Arias et al., 2014, see).

Our findings reveal that LOLR shocks affect the economy both in terms of macroeconomic outcomes and financial stability implications. First, a positive LOLR shock, reflecting more favorable central bank haircuts, triggers economically and statistically significant responses of unemployment and inflation. Both responses suggest delayed, but highly persistent, effects. Positive LOLR shocks result also in improved credit market conditions by reducing lending rates and increasing loan volumes to both firms and households, with no statistically meaningful differences across borrower types.[3]

Second, favorable LOLR shocks also reduce banks' funding costs and lower systemic financial risk. Bank bond spreads fall immediately and remain compressed over time, reflecting enhanced access to liquidity and increased demand for bank bonds as collateral.

[3]These findings are consistent with the micro-level evidence in Jasova et al. (2021), who, using granular credit registry data in a difference-in-differences setting, show that private credit in Portugal contracted by substantially less due to favorable LOLR haircut gaps.

The large and persistent response arises because a higher ECB haircut gap both improves banks' central bank refinancing terms and reduces bank bonds' illiquidity risk, boosting their collateral value, increasing demand, and lowering yields, consistent with evidence that such shocks lead banks to hold more bank bonds and strengthen the funding-cost channel of LOLR interventions (see Jasova et al., 2023).

Systemic risk, measured using the Brownlees and Engle (2017) metric, declines sharply on impact and remains below baseline in a persistent manner. This result is in line with classical LOLR doctrine that advocates generous central bank lending during crises to stabilize the financial system (see Bagehot, 1873b).

Third, the analysis examines whether central bank collateral haircut shocks affect money-market functioning, measured by dispersion in money-market yields, and finds—using an augmented VAR framework—that LOLR haircut shocks have no significant impact on money-market dispersion. Unlike conventional monetary policy shocks, haircut shocks do not generate meaningful movements in rate dispersion, consistent with the fact that haircut changes do not alter the aggregate supply or distribution of reserves.

Finally, we show that LOLR shocks are fundamentally distinct from monetary policy shocks. While both affect macroeconomic and financial conditions, they operate through different mechanisms and pursue different objectives. Monetary policy shocks produce immediate movements in unemployment, inflation, and the yield curve, while haircut shocks generate delayed responses, opposite effects on the slope of the yield curve, and neutrality in money-market dispersion. These differences underscore the need to treat the two instruments as empirically and conceptually separate. Monetary policy shocks trigger rapid declines in unemployment and a temporary steepening of the yield curve—patterns consistent with shocks that primarily affect short-term rates. By contrast, LOLR shocks affect real activity with substantial delay and flatten the yield curve at medium horizons, reflecting increased demand for bonds across maturities as banks rebalance portfolios in response to improved liquidity conditions.

The comparison of financial market outcomes further underscores these differences. Expansionary monetary policy produces a short-lived reduction in bank bond spreads and temporarily lowers systemic risk, while also significantly affecting money-market dispersion. LOLR shocks, in contrast, generate more delayed but highly persistent declines in bank funding costs, reduce systemic risk in line with their financial-stability mandate, and leave money-market functioning largely unaffected.

Taken together, the results show that LOLR policy has economically meaningful and durable effects on the macroeconomy through credit conditions and financial stability, while remaining distinct from monetary policy in terms of transmission, timing, and market impact. These findings support the joint modeling of the two instruments and suggest that central banks could, in principle, deploy collateral policy alongside interest rates as a separate and complementary policy lever.

Contribution to the literature. Our paper belongs to the large VAR literature that stresses the importance of credit variables for the transmission of monetary policy shocks to the macroeconomy (see e.g. Christiano et al., 1996; Gertler and Karadi, 2015). We contribute to this strand of the literature by assessing the impact of LOLR shocks, as opposed to policy rate shocks. Importantly, we focus on variables that capture more closely the transmission of LOLR shocks through the banking sector (e.g. bank loans and lending rates, systemic risk...), which is at the center stage of the debate on the effectiveness of LOLR policy. More broadly, we complement previous studies by providing a comprehensive assessment of the macro and financial stability implications of favorable LOLR policies.

Classic LOLR theory, originating in Bagehot (1873a), argues that lending freely against good collateral prevents panics, fire sales, and contagion. Yet recent empirical work suggests a more complex picture. Jasova et al. (2023) show that variation in collateral haircuts amplifies systemic interconnectedness by transmitting liquidity stress across banks. Acharya et al. (2018) demonstrate that weakly capitalized banks borrow more from the LOLR using lower-quality collateral and reallocate risk by purchasing risky sovereign bonds. Dewachter et al. (2015) find that the ECB's 3-year LTROs induced banks-especially weaker ones-to accumulate domestic sovereign debt, supporting carry-trade behavior. Ampudia and Van den Heuvel (2018) show that negative rates and excess liquidity compress bank margins and encourage rebalancing toward riskier assets. Borio and Zhu (2012) provide the theoretical foundation for the "risk-taking channel," emphasizing how accommodative policy shapes risk-taking incentives. While these contributions highlight important mechanisms, their methodologies do not capture general-equilibrium feedbacks across the macro-financial system. Our paper addresses this gap.

The rest of the paper is organized as follows. Section 1 describes the data and the construction of the LOLR haircut gap from security-level collateral and repo transactions. Section 2 provides micro-level evidence on how exogenous variation in the haircut gap affects bank-level lending, establishing the balance-sheet channel through which LOLR policy

operates. Section 3 studies the time-series properties of the haircut gap and develops an aggregate liquidity proxy that summarizes its informational content. Section 4 formalizes the econometric challenges involved in identifying exogenous movements in LOLR policy and motivates the need for narrative and information-based restrictions. Section 5 presents our identification strategy within a Bayesian VAR framework and describes the underlying motivation for the adopted narrative sign restrictions. Section 6 reports the macroeconomic and financial responses to LOLR shocks. Section 7 contrasts these effects with those of conventional monetary policy shocks, highlighting differences in transmission, timing, and market impact. Section 8 presents concluding remarks and discusses the positive and normative implications of our analysis.

1 Haircut Gap

The European Central Bank (ECB) provides liquidity to euro area banks through repurchase agreements (repos) using eligible assets as collateral. To ensure broad access across banks and countries, the ECB accepts a wide range of assets for liquidity operations.[4]

The amount of liquidity a bank can obtain depends largely on the haircut applied to pledged collateral. The ECB determines haircuts based on factors such as issuer type (e.g., government, bank), asset class (e.g., covered or uncovered bonds), coupon type (fixed or floating), credit rating, and residual maturity. The ECB publicly communicates its standard valuation matrix and any adjustments to its framework.[5] Additionally, it publishes a daily list of eligible securities (at the ISIN level), allowing precise observation of the haircuts applied in liquidity operations.[6]

Since October 2008, in response to the global financial crisis, the ECB has strengthened its lender-of-last resort (LOLR) function within monetary policy operations, offering unlimited liquidity to banks that pledge sufficient eligible collateral. Before the crisis, ECB haircuts were generally in line with private repo markets. However, in the aftermath, the ECB began applying significantly lower haircuts. Between 2009 and 2015, the ECB's average haircut was 5.9%, compared to an average haircut of around 12% in private markets.

[4]Securities used as collateral in liquidity operations must meet a minimum credit quality requirement, receiving a first-best credit assessment of at least credit quality step 3 (BBB- or equivalent) from external credit assessment institutions such as S&P, Moody's, Fitch, and DBRS.

[5]See https://www.ecb.europa.eu/paym/coll/risk/liquidity/html/index.en.html

[6]See https://www.ecb.europa.eu/paym/coll/assets/html/index.en.html

Following Bagehot's principle, the ECB provides unlimited liquidity against adequate collateral but at a "penalty" rate. Although it offers lower haircuts than private markets, effectively subsidizing collateral, it charges an interest rate above private repo rates. As a result, banks prefer private funding when haircut differentials are minimal.

1.1 Constructing the Haircut Gap

The ECB counterparties are all credit institutions (unconsolidated level) operating in the euro area and supervised according to harmonized EU standards. To measure the disconnect between the ECB and private repo market haircuts we compile a unique micro-level dataset that combines ECB data - linking the securities banks hold and pledge for LOLR funding - with the haircuts applied by both the ECB and private repo markets for each individual security (ISIN-level), alongside bank balance sheet data. This granularity allows for an in-depth analysis of LOLR funding across the euro area. In this section, we describe the various data sources, before turning to the empirical framework.

1.1.1 Dataset

Central bank liquidity and collateral data. The Market Operations Database (MOPDB) is the ECB's most comprehensive dataset on liquidity operations and collateral pledged by European banks. Covering over 19 countries, 2,000 counterparties, and 30,000+ securities, it provides detailed International Security Identification Number (ISIN)-level information on issuer group (bank, government,...), security type (bond, note, covered bond, ABS...), issuance and maturity date, security guarantor and valuations (market value, ECB haircut and haircut-adjusted value). This, in addition to the amount pledged by each individual entity and the total amount outstanding. By offering ISIN-level data, the dataset enables a precise analysis of LOLR funding, capturing its impact with exceptional granularity and coverage.

Private market haircuts. We collect private repo market haircuts from the two leading exchange and clearing houses in Europe - LCH Clearnet and EUREX - for securities of different type, rating and maturity at monthly frequency.

Securities and issuer ratings. The Eurosystem Centralized Securities Database (CSDB) consolidates security-by-security data (instruments, issuers and prices) from both internal

and commercial sources. Ratings on the credit quality of marketable securities according to the Eurosystem external credit assessment institutions - S&P, Moody's, Fitch and DBRS - are observed at the ISIN-time and issuer-time level for all securities issued by EU residents or denominated in euro.

Bank-level data. In order to identify the pledging of own bank bonds or bank bonds issued by banks within the same group, we use the data on bank ownership structure from Bankscope and Register of Institutions and Affiliates Database (RIAD) to construct the group structure of banks. Furthermore, to study the credit effects of changes in the Haircut gap, we use proprietary Individual Balance Sheet Items (IBSI) database maintained by the ECB which contains monthly-level information on the granular asset and liability categories for about 340 banks (unconsolidated level) operating in the euro area.

1.1.2 Methodology

The haircut gap is measured as the difference between the ECB and private market haircuts of a specific pledged security type s at time t:

$$\text{HaircutGap}_{s,t} = \text{ECB haircut}_{s,t} - \text{private market haircut}_{s,t} \tag{1}$$

where the security type s is defined over the following characteristics: issuer group, issuer rating and residual maturity basket. Table 1 (top panel) provides the detailed summary statistics. Across all securities, the mean haircut gap is 9.94 percentage points (standard deviation 19.6): ECB haircuts average 5.9%, while private-market haircuts average approximately 12%.

2 Credit Effects: Micro-Level Evidence

Is LOLR funding associated with higher lending to the private sector? In this subsection, we motivate the main question of our paper by examining bank-level data and measuring the correlation between a bank's specific average haircut gap and its lending behavior.[7]

Measuring Exposure to LOLR. First, we aggregate the haircut gap at the bank level.

[7]Previous work has showing similar evidence focusing on specific countries. This is the first paper to focus on the whole euro area

For each bank at a given time, we calculate the haircut gap as a weighted average of security-level haircut gaps across all pledged securities, normalized by the bank's total assets. This defines the bank-level haircut gap as follows:

$$\text{HaircutGap}_{b,t} = \frac{\sum_s \left(\text{HaircutGap}_{s,t} \times Q_{b,s,t=2008m8} \right)}{\text{total assets}_{b,t-1}}, \tag{2}$$

where $Q_{b,s,t=2008m8}$ represents the value of the security s pledged by bank b with the ECB. To isolate the direct effect of LOLR funding on banks' pre-existing security portfolios and avoid biases from subsequent portfolio adjustments, we construct our exposure measure based on securities pledged as of August 2008-before a significant divergence emerged between ECB and private repo market valuations. Banks with a larger haircut gap were those whose borrowing capacity was most affected by the ECB's expanded LOLR function.[8]

Figure 2c illustrates the evolution of dispersion in banks' haircut gaps, highlighting significant cross-sectional variation at the bank level. In line with LOLR interventions, the largest haircut gaps and the widest dispersion occurred during the Sovereign Debt Crisis. Table 1 (bottom panel) provides a summary of key bank-level data. During the 2009–2015 period, the average haircut gap at the bank level was approximately 0.22% of total assets, with sizable differences across banks (standard deviation of about 0.66%).

Empirical Specification. We leverage the cross-sectional variation in banks' haircut gaps to assess the impact of LOLR funding on lending outcomes at the bank level. To do so, we merge data on the size of the haircut gap at the bank level with monthly unconsolidated balance sheet data from euro area banks. Equation 3 summarizes the set-up:

$$log(\text{credit}_{b,t}) = \alpha_b + \alpha_{c,t} + \beta \text{HaircutGap}_{b,t-1} + \gamma X_{b,t} + \epsilon_{b,t}, \tag{3}$$

where $log(credit_{b,t})$ is log amount of credit granted to the private sector by bank b at month t. We exploit the variation in haircut gap at the cross-section of banks, as described by equation 2.

[8] In October 2008, the ECB departed from its conventional liquidity operations framework to assume its LOLR responsibilities. Only after this shift did the valuation of eligible collateral begin to diverge between the ECB and private repo markets.

Our identification strategy faces two key challenges. First, changes in the bank-level haircut gap may result not only from LOLR policy shifts but also from endogenous adjustments to banks' security portfolios. To address this, we use an ex-ante measure of exposure to LOLR policy, defining bank-level haircut gaps based on securities pledged as of August 2008 (see equation 2). Second, the haircut gap may correlate with the market valuation of a bank's securities portfolio, which could in turn influence lending decisions. To mitigate this concern, we control for the time-varying value of banks' security portfolios.

To further strengthen our identification, we incorporate multiple fixed effects. First, we include time fixed effects (α_t) to account for any time-varying factors. Second, we add country-time fixed effects ($\alpha_{c,t}$) to absorb time-varying country-specific fluctuations in credit demand. Third, we control for bank fixed effects (α_b) to capture time-invariant bank characteristics that may be correlated with the haircut gap measure. Additionally, we control for time-varying bank characteristics ($X_{b,t}$) such as capital ratios, total assets, and the value of the bank's securities portfolio as a share of total assets.

Credit to Firms and Households. Table 2 presents the results for lending to non-financial firms (Columns (1)–(2)), denoted as *NFC*, and lending to households (Columns (3)–(4)), denoted as *HH*. Across all specifications, the coefficient estimate of β is positive and statistically significant, indicating that banks with larger haircut gaps provided greater support for domestic private-sector lending during the financial and sovereign debt crisis.[9]

Comparing the estimates with and without country-time fixed effects reveals that failing to control for overall credit demand at the country level (Columns (1) and (3)) somewhat overstates the policy's impact on lending, particularly for households. When country-time fixed effects are introduced, the estimates decrease in magnitude but remain positive, stable, and statistically significant. In terms of economic significance, a one-standard-deviation increase in the haircut gap is associated with an approximately 2.6 percent increase in lending to firms and with a 3.5 to 5 percent increase in lending to households.

In summary, our results indicate that by increasing the borrowing capacity of banks holding securities with larger haircut gaps, LOLR policy had a positive impact on domestic lending to both firms and households.

[9]Our results are based on unconsolidated bank-level data and, therefore, capture the direct impact of LOLR funding on domestic private-sector lending.

3 Macro-level Evidence

The bank-level evidence presented in the previous section suggests that the effects of idiosyncratic changes to the haircut gap might also have an impact on the aggregate economy. Indeed, our empirical findings, summarized in Table 2, establish a robust relationship between individual banks' exposure to haircut gaps and their subsequent credit extension. Specifically, we find that banks experiencing higher idiosyncratic haircut gaps in the previous period are associated with a systematic increase in their credit supply in the following period. This lays ground to the possibility of constructing a proxy for exogenous shocks to the haircut gap, as in (2), using the granularity of both the bank credit size distribution and the distribution of banks holding a specific type of bond.

These correlations are presented as preliminary evidence intended to establish the relevance of the haircut gap as an informative variable or proxy. For the proxy to serve as a valid instrument, however, its exogeneity must be established. The next subsections discuss the limitations of using such a proxy directly as an instrument and explain how our methodology addresses potential endogeneity concerns.

3.1 Purging the Endogenous Policy Response

The proxy in Eq.(2) captures both the endogenous reaction of policy to evolving macroeconomic and financial conditions, and the exogenous policy stimulus that the central bank aims to extend. To isolate the endogenous component of the haircut subsidy provision, we leverage the microstructure of the data. Specifically, we use the following fixed effects regression:

$$\text{HaircutGap}_{b,s(c),bank,t} = \alpha_{b,t} + \alpha_{c,t} + \varepsilon_{b,s,t} \tag{4}$$

where $\alpha_{b,t}$ and $\alpha_{c,t}$ are bank-time and country-time fixed effects, respectively.

Although the central bank (CB) sets haircuts for individual securities without discriminating based on the country of residence or domicile of the holding bank, it can still influence particular countries more than others by favoring certain securities. As such, haircut policy decisions may be adjusted to address asymmetric country-level needs. This is the component of the liquidity provision policy that is endogenous to the economic and financial conditions of each country. The fixed effect term $\alpha_{c,t}$ captures this source of endogeneity.

Similarly, some types of banks may typically have portfolios skewed toward specific asset classes. The CB, aware of these structural differences, may set haircuts in a way that

indirectly targets particular types of financial institutions. The bank-time fixed effect $\alpha_{b,t}$ captures this second source of endogeneity.

The residual term $\varepsilon_{b,s,t}$ measures the haircut gap faced by a specific bank in a given country, netting out the average haircut gap faced by other banks in the same jurisdiction and controlling for time-varying characteristics of bank types.

This residual is the input into the construction of an aggregate excess-liquidity proxy, which we construct by aggregating across all bank holdings of different securities, in line with Eq.(4). Specifically,

$$\begin{aligned}\text{Aggregate Haircut Gap}_t &= \sum_{s,b} \varepsilon_{b,s,t} \times \frac{\text{Amount Pledged}_{b,s,t}}{\text{Total Amount Pledged}_t} \\ &= \sum_{s,b} \varepsilon_{b,s,t} \times \underbrace{\frac{\text{Amount Pledged}_{s,b,t}}{\text{Total Amount Pledged}_{b,t}}}_{\text{Granularity in security holdings at the bank level}} \times \underbrace{\frac{\text{Amount Pledged}_{b,t}}{\text{Total Amount Pledged}_t}}_{\text{Granularity in bank size}}\end{aligned} \tag{5}$$

Note that after removing the endogenous policy component at the micro level as per Eq.(4), the remaining exogenous component $\varepsilon_{b,s,t}$ loses much of its commonality and dependence (which largely reflects country and bank variation).

Yet, the aggregation in Eq.(5) retains its aggregate significance due to the granularity of the weights (see Gabaix (2011)). Specifically, the distribution of bank holdings at the security-level is highly non-uniform across banks. For instance, a primary source of this non-uniformity is the so-called home bias in security allocations by banks. Moreover, some banks naturally pledge much higher volumes of securities, which is reflected in the highly skewed distribution of bank asset sizes.

In this respect, it is useful to compare Figure 2b and Figure 3. The former reports HaircutGap_t, while the latter aggregates LiquidityProxy_t. The aggregated haircut gap is, on average, positive, a reflection of the CB performing its LOLR role by accepting securities at a lower discount than the market would impose.

There is also a clear upward trend from 2010 to 2013, which gradually reverses thereafter. This pattern suggests that, during the height of the euro area sovereign debt crisis, the CB adopted a more accommodative stance regarding liquidity provision, which it slowly unwound over time.

In contrast, Figure 3 does not exhibit such a trend. This suggests that the accommodative policy was, to a large extent, an endogenous response by the central bank (CB) to evolving macro-financial conditions. Once this predictable, endogenous component is netted out, Figure 3 reveals that during the early phase of the EA crisis (2010–2012), LOLR policy

remained relatively balanced. However, following Draghi's "whatever it takes" speech and continuing through 2014, there is clear evidence of exogenous LOLR support, which then quickly recedes. As a result, the explicit accommodative policy bias largely disappears thereafter.

4 Perils in the Identification of Policy-Induced Liquidity Provision Shocks

In principle, one might consider the Liquidity Proxy just constructed as a direct measure of exogenous central bank (CB) liquidity policy. In that case, one could evaluate the macroeconomic impact of such policies by including the proxy in a VAR and identifying the transmission of the policy shock through a simple recursive identification approach.

Yet, it is important to consider the risks of making such an oversimplifying assumption. Specifically, even after accounting for the endogenous component of policy, the Liquidity Proxy may still contain a non-policy component and be contaminated by measurement error.

There are at least two possible interpretations of the non-policy component in our proxy. First, since the gap captures the discount applied by the CB relative to the market haircut, it can vary not only due to policy decisions but also because of market deteriorations or improvements that are not immediately offset by the CB. Thus, a slow-moving policy response in the face of fast-moving financial markets implies that the Liquidity Proxy derived from the haircut gap contains both a policy-driven component and another component reflecting external shocks affecting market liquidity.

Second, markets may extrapolate from the CB's haircut decisions its private information or perceptions regarding liquidity stress in particular markets. As a result, the intervention carries both a policy component and an informational component about the likely provision of liquidity by the CB.[10]

For the sake of exposition, let us assume that the proxy of liquidity LiquidityProxy_t is i.i.d. and includes three components:

$$\text{LiquidityProxy}_t = \xi_t^P + \xi_t^{NP} + \epsilon_t$$

where $\xi_t^P \sim \mathcal{N}(0, \sigma_P^2)$ and $\xi_t^{NP} \sim \mathcal{N}(0, \sigma_{NP}^2)$ denote the policy and non-policy components

[10]This is analogous to the "information channel" in the traditional identification of monetary policy shocks.

of the liquidity proxy, and $\epsilon_t \sim \mathcal{N}(0, \omega^2)$ represents measurement error. Assume that each of these components is i.i.d. and mutually uncorrelated.

Let us consider a generic vector of endogenous variables $\mathbf{y}_t = [y_t^1, \ldots, y_t^N]'$, where, for a generic variable j, v_t^j is the reduced-form innovation in the VAR associated with that variable. Specifically, assume that the variable of interest is affected by the two liquidity components and other shocks:

$$v_t^j = a_{j,P}^0 \xi_t^P + a_{j,NP}^0 \xi_t^{NP} + \sum_{i=1}^{N-2} b_{j,i}^0 \eta_{it}$$

where η_{it} denotes other shocks.

Now consider what happens if LiquidityProxy_t is used directly as a proxy for the relevant shock within a VAR. Estimating a VAR for the augmented vector $\widetilde{\mathbf{y}}_t = [\text{LiquidityProxy}_t, \mathbf{y}_t]'$ identifies the following contemporaneous impulse response for a generic variable y_t^j:

$$\begin{aligned} \hat{a}_{j,L}^0 &= \frac{\text{Cov}(v_t^j, \text{LiquidityProxy}_t)}{\text{Var}(\text{LiquidityProxy}_t)} \\ &= \varkappa \left[w_P a_{j,P}^0 + (1 - w_P) a_{j,NP}^0 \right] \end{aligned}$$

where $w_P = \frac{\sigma_P^2}{\sigma_P^2 + \sigma_{NP}^2}$ and $\varkappa = \frac{\sigma_P^2 + \sigma_{NP}^2}{\sigma_P^2 + \sigma_{NP}^2 + \omega^2}$.

The presence of measurement error in the construction of the Liquidity Proxy, i.e. for $\omega^2 > 0$, generates attenuation bias in the estimated response to liquidity, as it implies that $\varkappa < 1$.

Most importantly, in the presence of heterogeneous responses to liquidity variation-that is, when $a_{j,P}^0 \neq a_{j,NP}^0$-the estimated response to liquidity provision does not necessarily reflect the true response to policy. In fact, the estimate can be severely biased when the effects of the policy and non-policy components of LiquidityProxy_t differ substantially.

To sum up, unless the Liquidity Proxy is a pure measure of policy-induced variation in liquidity provision (i.e., $\sigma_{NP}^2 = \omega^2 = 0$), the policy shocks retrieved using a recursive ordering assumption in a VAR augmented with the proxy (ordered first) will yield a biased estimate of the true response of any macroeconomic variable to the shock of interest.

5 Novel Empirical Approach

To address these challenges, we follow a more robust strategy: we incorporate the proxy into a VAR model and impose a limited set of narrative restrictions during periods when haircut policy shocks are known to be particularly relevant. This approach allows us to capture the impact of the shock of interest in a disciplined but flexible way, while fully exploiting the informational value of the proxy.

The structural SVAR model we estimate is given by:

$$\mathbf{y}_t'\mathbf{A}_0 = \sum_{l=1}^{p} \mathbf{y}_{t-l}'\mathbf{A}_l + \mathbf{c} + \boldsymbol{\varepsilon}_t', \quad 0 < t < T \tag{6}$$

where $\mathbf{y}_t$ is an $n \times 1$ vector of endogenous variables, $\boldsymbol{\varepsilon}_t$ is an $n \times 1$ vector of structural shocks, $\mathbf{A}_0$ is an invertible matrix of contemporaneous relations, $\mathbf{A}_l$ are $n \times n$ matrices of lagged coefficients for $l = 1, \ldots, p$, $\mathbf{c}$ is a $1 \times n$ vector of constants, and T denotes the sample size. We assume that, conditional on the information set up to $t-1$, the structural shocks $\boldsymbol{\varepsilon}_t$ are Gaussian, mutually uncorrelated, and have zero mean and unit variance.

The reduced-form representation of the model is:

$$\mathbf{y}_t' = \sum_{l=1}^{p} \mathbf{y}_{t-l}'\mathbf{B}_l + \mathbf{d} + \mathbf{u}_t', \quad 0 < t < T \tag{7}$$

with $\mathbf{B}_l = \mathbf{A}_l\mathbf{A}_0^{-1}$, $\mathbf{d} = \mathbf{c}\mathbf{A}_0^{-1}$, and the reduced-form residuals $\mathbf{u}_t$ having variance-covariance matrix $\boldsymbol{\Sigma} = (\mathbf{A}_0\mathbf{A}_0')^{-1}$. Given the parameter set $\boldsymbol{\Theta} = (\mathbf{c}, \mathbf{A}_0, \{\mathbf{A}_l\}_{l=1}^{p})$, the structural shocks are a linear function of the reduced form innovations:

$$\boldsymbol{\varepsilon}_t'(\boldsymbol{\Theta}) = \mathbf{u}_t'\mathbf{A}_0 \tag{8}$$

Our identification strategy follows the methodology proposed by Antolín-Díaz and Rubio-Ramírez (2018). We use external narrative information to identify a limited number of dates where policy-driven haircut shocks are known to have occurred, specifying the direction (expansionary or contractionary) and sign of the shock. We then impose sign and magnitude restrictions directly on the structural residuals associated with these events.

Unlike Antolín-Díaz and Rubio-Ramírez (2018), we do not impose sign restrictions on impulse responses, aside from the normalization assumption that policy-induced variation

in the haircut gap increases LiquidityProxy_t. This reflects our cautious stance: we do not assume ex ante knowledge of the full dynamic effects of haircut shocks. By restricting only the signs and relative sizes of structural shocks at known policy dates, we retain flexibility in the model's response while ensuring credible identification of the shock of interest.

5.1 Identification Narrative

Narrative information used to elicit the narrative sign restrictions builds on two historical events. The LOLR shock must take a non-negative value in January 2011 and December 2011 and is the most important contributor to the observed unexpected movements in the haircut gap. On both dates, the ECB kept haircuts on the securities issued by peripheral economies at significantly lower levels.

It is important to emphasize four main subtleties with respect to the strength of the identification strategy employed here.

First, our strategy explicitly allows for the possibility that a substantial fraction of the unexpected movements in the information variable reflects endogenous policy responses to contemporaneous external developments. The identifying assumption therefore amounts to requiring that, on those dates, any exogenous deviation from the normal policy rule was not pointed at offsetting the forces implied by the rule itself, but rather to reinforce them. In other words, in order for non-negative restrictions to be valid it is just needed that the shock did not act in the opposite direction with respect to the policy induced movement in our information variable. Second, we only impose a sign restriction on one variable, which is purely a normalization: this amounts to normalizing our object of interest to be an exogenous impulse resulting in a positive change of our informative variable. Third, we impose a magnitude restriction requiring that, on each of the narrative dates, the contribution of the identified shock to the historical decomposition be larger in absolute value than the contribution of any other individual shock. Hence, this restriction does allow for the possibility that multiple shocks occurred within the same narrative dates and jointly explained a larger share of the variation in the information variable. The only requirement needed to validate our restriction is that no single alternative shock dominated the impact contribution of the identified innovation at each of the narrative dates.

Narrative Sign Restriction 1. In January 2011 Fitch downgraded Greece's credit rating from BBB- to BB+. Securities eligible as collateral for LOLR operations need to meet the minimum requirement of a first best credit assessment of at least credit quality

step 3 (rating of BBB- or equivalent) obtained from external credit assessment institutions (S&P, Moody's, Fitch and DBRS).[11] Fitch was the last of the three major agencies to rate Greek debt below investment grade. By January 2011, the three major rating agencies had all reduced Greece's debt to below investment grade. In May 2010, the ECB had, however, suspended the application of the minimum credit rating threshold on Greek sovereign debt. The suspension applied to all outstanding and new marketable debt instruments issued or guaranteed by the Greek Government.[12] Therefore, since then, Greek debt remained eligible as collateral in ECB lending operations, even if rating agencies continued to downgrade Greece in the wake of the Sovereign debt crisis.[13] So, while private market repo clearing houses responded by increasing the haircut on the securities issued by peripheral economies, the ECB kept those haircuts at significantly lower levels.

Narrative Sign Restriction 2. In the second half of 2011, the sovereign debt crisis had spread beyond Greece and was causing a major loss of confidence in the eurozone's banking sector, with rising borrowing costs for most peripheral euro area countries. On 26 November 2011 Fitch Ratings downgraded Portugal's long-term credit rating to BB+ from BBB-, moving it into speculative-grade status. On 5 December 2011 Standard and Poor's placed 15 out of the 17 euro area Member States on "credit watch with negative implications", threatening potential downgrades also for six countries with top AAA ratings like France and Germany. The action signaled a high probability of downgrades within 90 days. On 8 December 2011, the ECB unexpectedly announced a new Very Long-Term Refinancing Operation (vLTRO).[14] The first such operation, which took place on 21 December 2011, provided EUR 489.2 billion to 523 credit institutions.[15] Importantly, the vLTRO was introduced when the ECB was providing banks with a favorable gap between the central bank

[11]To make the credit ratings comparable across systems and sources, the grades are mapped to a harmonized rating scale. For detailed information on the Eurosystem's harmonized rating scale, see https://www.ecb.europa.eu/paym/coll/risk/ecaf/html/index.en.html.

[12]ECB announces change in eligibility of debt instruments issued or guaranteed by the Greek government https://www.ecb.europa.eu/press/pr/date/2010/html/pr100503.en.html

[13]The waiver of minimum credit rating requirements was suspended only in February 2015. https://www.ecb.europa.eu/press/pr/date/2015/html/pr150204.en.html and then restored in June 2016 ECB reinstates waiver affecting the eligibility of Greek bonds used as collateral in Eurosystem monetary policy operations https://www.ecb.europa.eu/press/pr/date/2016/html/pr160622˙1.en.html

[14]ECB announces measures to support bank lending and money market activity https://www.ecb.europa.eu/press/pr/date/2011/html/pr111208˙1.en.html

[15]The newly available long-term funding was offered at exactly the same conditions as for the existing short-term repo. Overall, more than 800 banks participated to the vLTRO and the ECB allotted approximately EUR 1 trillion of funding.

and private market haircut on the value of risky securities pledged to obtain repo funding.[16] Indeed, not only Portuguese debt remained eligible as collateral in ECB lending operations[17] but the ECB kept haircuts on the securities issued by peripheral economies at significantly lower levels.

As a robustness check, we also rely on June 2014, i.e. the date of announcement of the first Targeted Longer-Term Refinancing Operations (TLTRO) program to support bank lending to the euro area's real economy.[18]

6 Results

6.1 Baseline Specification

We estimate the aggregate effects of LOLR shocks using the sign and narrative restrictions described in the previous section. Our baseline Bayesian VAR is estimated at monthly frequency and includes the aggregate haircut gap, the unemployment rate, headline inflation, and the EONIA rate. To ensure stationarity, all non-stationary variables are expressed as deviations from their long-run steady state, constructed using a two-year log difference, following the approximation proposed by Hamilton (2018).

Impulse response functions (IRFs) are reported as deviations from the unconditional mean of each variable. Figure 6 presents the estimated responses to a LOLR liquidity shock, normalized to induce a one-percentage-point increase in the aggregate haircut gap. This normalization permits a direct economic interpretation of the shock as an exogenous relaxation of central bank collateral constraints relative to private repo markets, consistent with the micro-level evidence on haircut gaps.

All variables exhibit economically and statistically significant responses to the LOLR shock. Reassuringly, the EONIA rate displays no contemporaneous response, indicating that the identified liquidity shock is orthogonal to conventional monetary policy at impact and does not require the imposition of an ad hoc sign restriction on short-term interest rates. Real activity and prices respond with a delay: unemployment and inflation decline by approximately 0.4 and 0.1 percentage points, respectively, with peak effects occurring after

[16] Together with the announcement of the vLTRO, the ECB also relaxed collateral rules on risky asset-backed securities and allowed national central banks to temporarily accept non-marketable securities.

[17] ECB announces change in eligibility of debt instruments issued or guaranteed by the Portuguese government. https://www.ecb.europa.eu/press/pr/date/2011/html/pr110707˙1.en.html

[18] See https://www.ecb.europa.eu/mopo/implement/omo/tltro/html/index.en.html

roughly two and a half years. Both responses are highly persistent, with economically meaningful effects extending over a horizon of up to five years. The unemployment gap remains about 0.2 percentage points below its steady state even five years after the shock, while the EONIA rate remains lower by roughly 0.1 percentage points over the same horizon.[19]

Narrative Information. To assess the incremental identifying power of the narrative sign restrictions, we examine the implied distributions of the structural LOLR shocks estimated in our baseline VAR and compare them with those obtained from an otherwise identical VAR estimated without imposing narrative restrictions. Figure 5 reports this comparison.

Panels 4a and 4b display, respectively, the distributions of the LOLR shocks at the narrative dates, with the red histograms corresponding to the VAR estimated under narrative sign restrictions and the blue histograms to the unrestricted VAR. We report the distributions for each of the three dates at which narrative restrictions are imposed.

Across all three episodes, the distributions of shocks obtained under narrative restrictions differ markedly from those estimated without these restrictions, indicating that the narrative restriction is informative for identification. For the first two episodes—January 2011 and December 2011—the distributions exhibit limited overlap. In these cases, the mean, median, and mode of the restricted distributions are all substantially shifted relative to their unrestricted counterparts, pointing to strong identifying content in the narrative restrictions.

By contrast, the differences in shock distributions are less pronounced for June 2014. While the left tail and the mean of the restricted distribution remain clearly separated from those of the unrestricted VAR, the median and mode are noticeably closer. This pattern is reassuring. Among the three episodes, June 2014 is a priori the least informative from an identification standpoint, given the nature of the underlying policy events in that month (see Section 5). The weaker separation in this case is therefore consistent with the relative weaker strength of the narrative information in this episode.

6.2 Transmission via Credit and Financial Variables

In this subsection, we extend the baseline VAR specification to include additional variables that allow us to further characterize the effects of LOLR shocks and to shed light on the underlying transmission channels.

[19] In the Appendix we compare the IRFs of our baseline identification scheme with a simpler recursive scheme. See Figure 7

Credit Market Conditions. We begin by examining credit as the primary transmission channel of LOLR shocks. This is a natural focus, as banks are the only sector with direct access to collateralized liquidity from the European Central Bank. Consequently, any liquidity shock originating from the Eurosystem should affect bank lending decisions. To assess whether such shocks are amplified through bank lending, we augment the baseline VAR with measures of loan volumes and lending rates for both non-financial corporations (NFCs) and households.[20] Including credit variables for both borrower groups allows us to examine potential heterogeneity in the transmission of LOLR shocks across lending segments. Figure 8 reports the corresponding impulse responses.

The estimated impulse responses reveal a significant and persistent reaction in both lending rates and loan volumes. For credit to non-financial corporations, the average new-business lending rate begins to decline approximately eight months after the shock, reaches a trough of about 0.1 percentage point, and gradually reverts toward its steady state over the subsequent three years. Corporate loan volumes respond with a similar delay, becoming statistically significant after roughly ten months and peaking at approximately 2% above baseline around twenty-five months after the shock. Responses in the household sector are broadly comparable. The average interest rate on household loans declines by about 0.2 percentage points at its trough, while household loan volumes increase by approximately 1% relative to baseline. These findings are consistent with the micro-level evidence in Jasova et al. (2021), who—using granular credit registry data and a Khwaja and Mian (2008)-style identification strategy—show that private credit in Portugal would have contracted by substantially more in the absence of LOLR interventions. The 90% credible intervals for NFC and household credit responses overlap substantially, indicating no statistically significant difference in the aggregate lending response across borrower types.[21]

Bank Bond Spreads. Several channels may account for the transmission of LOLR shocks to bank lending to the real economy. We examine the impact of LOLR interventions on banks' funding costs. This channel is motivated by a substantial literature showing that large central bank liquidity injections ease short-term refinancing constraints and thereby reduce banks' marginal funding pressures. For example, Acharya et al. (2019) document

[20] Loan volumes are expressed as deviations from their long-run trend, consistent with the transformation applied to the unemployment gap.

[21] Differences in point estimates likely reflect structural differences in the long-run levels of corporate and household credit, as well as variation in the interest-rate elasticity of loan demand across segments.

that the ECB's three-year LTROs significantly lowered bank CDS and bond spreads, underscoring the ability of LOLR liquidity to compress risk premia and alleviate funding stress.[22] Carpinelli and Crosignani (2021) further interpret the LTROs as exogenous liquidity shocks that prompted meaningful adjustments in banks' funding structures and credit supply.

In our empirical setting, we assess the effect of LOLR shocks on banks' funding costs by introducing a measure of average bank credit spreads, defined as the monthly difference between bank bond yields and a matched-maturity risk-free benchmark; following Gilchrist and Mojon (2018), we derive our risk-free yields from German treasuries. Figure 2a shows that a positive LOLR shock - corresponding to an increase in the haircut gap - produces a large and persistent decline in bank funding costs. Bank bond spreads fall immediately by approximately 0.4 percentage points on impact and remain significantly compressed for more than five years.

The magnitude and persistence of this response reflect two complementary mechanisms. First, because bank bonds are eligible collateral at the ECB, an increase in the haircut gap improves the terms at which banks can refinance through central bank operations. Second, the associated reduction in illiquidity risk enhances the attractiveness of bank bonds as collateral more broadly, including in private repo markets, thereby increasing demand and lowering yields. These findings are consistent with Jasova et al. (2023), who show that positive shocks to the haircut gap induce banks to accumulate additional bank bonds, reinforcing the funding-cost channel of LOLR interventions.

Systemic Risk. The classical LOLR doctrine, dating back to Bagehot's Lombard Street (1873), prescribes that during periods of financial distress central banks should lend freely to solvent but illiquid institutions—against good collateral and at a penalty rate—to prevent runs, fire sales, and panic dynamics, thereby containing contagion and systemic risk. More recent contributions, however, emphasize that LOLR interventions may also foster greater interconnectedness and risk-taking, potentially increasing systemic vulnerability (see e.g. Jasova et al., 2023; Acharya et al., 2018; Dewachter et al., 2015; Ampudia and Van den Heuvel, 2018; Borio and Zhu, 2012). Taken together, these competing mechanisms imply that the net general-equilibrium effect of liquidity provision on systemic risk is theoretically ambiguous and ultimately an empirical question.

[22] Similar conclusions are reported in the ECB Economic Bulletin chapter on "TLTROs and Bank Lending Conditions" (Barbiero et al. (2019)), where TLTRO operations are shown to improve banks' refinancing conditions and strengthen the pass-through of monetary accommodation to longer-term funding markets.

In this subsection, we contribute to this debate by estimating—within our VAR framework—the general-equilibrium response of systemic financial risk to an exogenous shock to LOLR haircut policy. As a measure of systemic risk, we use the SRISK index of Brownlees and Engle (2017), a widely employed forward-looking indicator of the expected capital shortfall of the financial sector. The resulting impulse responses, reported in Figure 2b, indicate that systemic risk declines sharply on impact, by approximately 0.3 percentage points, and remains significantly below its baseline level for roughly three years.

This dynamic likely reflects the timing with which the opposing forces described above materialize. In the short run, LOLR interventions reduce systemic risk by easing funding constraints, mitigating liquidity shortages, and dampening contagion and panic dynamics. As financial conditions normalize, however, banks gradually rebalance their portfolios, increase interconnectedness, and engage in leveraged risk-taking, which progressively offsets the initial stabilizing effects. As a result, systemic risk converges back toward its pre-shock level more rapidly than other macro-financial variables, consistent with the notion that risk-taking responses operate with shorter horizons than real-side adjustments.

Money Market Dispersion. Finally, a further potential transmission channel operates through money-market functioning, as captured by dispersion in money-market yields. Duffie and Krishnamurthy (2016) show that monetary policy actions can either increase or reduce such dispersion by reshaping the distribution of central bank reserves and overall liquidity conditions, and that the effectiveness of policy in steering short-term rates hinges critically on the smooth transmission of these impulses across money markets. By analogy, a natural question is whether similar effects arise in response to shocks to central bank collateral haircuts.

To investigate this possibility, we augment the baseline VAR with a measure of money-market rate dispersion, constructed following Duffie and Krishnamurthy (2016). The resulting impulse responses are reported in Figure 2c. We find that an LOLR shock has no statistically significant effect on money-market dispersion on impact, and only a small and statistically weak response at intermediate horizons, significant at approximately the 64% credible level. These results indicate that LOLR shocks are largely neutral with respect to money-market functioning.

This result is intuitive: unlike conventional monetary policy actions that operate through changes in the aggregate supply of reserves, adjustments to collateral haircuts primarily affect

the terms of access to central bank liquidity without materially altering reserve quantities. As a result, the reserve-distribution and pass-through mechanisms emphasized by Duffie and Krishnamurthy (2016) are unlikely to be activated by haircut policy.

Finally, it is worth noting that the impulse responses of the baseline macroeconomic and financial variables—unemployment, inflation, and the short-term interest rate—remain remarkably stable across all augmented specifications, underscoring the robustness of our main results.

7 Comparison with Policy Rate Shocks

Are LOLR shocks and policy rate shocks fundamentally distinct? While both collateral haircuts and policy rates represent two distinct margins of central bank intervention and both instruments can influence macroeconomic and financial conditions, they operate through different mechanisms and are guided by different policy objectives. Our baseline results indicate that favorable LOLR shocks generate expansionary effects on real activity, credit aggregates, interest rates, and bank bond spreads that are broadly comparable in magnitude to those of conventional monetary policy shocks. In this subsection, we compare the two shocks directly to investigate potential differences and to assess whether our identification strategy effectively disentangles LOLR shocks from monetary policy shocks.

We identify the monetary policy shock using standard zero restrictions on the contemporaneous impact matrix, restricting unemployment and inflation to have no immediate response. Consistent with the construction of our haircut-gap measure, we also restrict the latter to have a zero contemporaneous response to a monetary policy shock.[23]. Because unemployment and inflation are restricted to have no contemporaneous response, we augment the specification with an additional unrestricted variable. We choose a proxy for the slope of the yield curve, for which theory delivers sharp predictions regarding both the sign and timing of the response to monetary policy disturbances.

Figure 10 reports the resulting impulse responses. The two shocks are clearly distinct. Following a monetary policy shock, unemployment declines quickly and becomes highly significant at much shorter horizons than in the case of a haircut-gap shock. Inflation initially falls but subsequently turns positive and statistically significant at medium horizons. The slope of the yield curve exhibits a sharp but transitory increase, consistent with a

[23]This restriction is not binding, as time fixed effects are employed in the construction of the haircut gap.

monetary policy shock that primarily affects short-term rates while leaving long-term yields comparatively stable.

In contrast, following a LOLR shock, unemployment responds significantly only with a considerable delay, inflation displays no discernible reaction, and the yield curve slope shows a delayed, negative, and significant response at medium horizons. This pattern is consistent with the mechanism emphasized by Jasova et al. (2023), who find that positive LOLR shocks induce banks to increase their holdings of government and bank bonds. The resulting increase in demand raises bond prices and compresses yields across maturities, leading to a flattening of the yield curve.

We further compare the two policy shocks by examining their effects on bank bond spreads, systemic financial risk, and money-market functioning. Figure 11 presents the results for monetary policy shocks, normalized to reduce the short-term policy rate by one percentage point. Expansionary monetary policy generates an immediate decline in bank bond spreads, although the effect dissipates after roughly one year. By contrast, LOLR shocks exhibit a more delayed but substantially more persistent impact on bank funding costs (Figure 2a). Systemic risk does not respond contemporaneously to monetary policy shocks, but declines significantly at short horizons before reverting toward baseline within approximately two and a half years. This dynamic underscores the different objectives of the two instruments: LOLR policy is explicitly designed to mitigate financial distress, whereas monetary policy primarily targets inflation and real activity, subject to the central bank's mandate.

Finally, consistent with Duffie and Krishnamurthy (2016), monetary policy shocks exert economically meaningful and statistically significant effects on money-market dispersion, as shown in Figure 11. In contrast, LOLR haircut shocks are essentially neutral with respect to money-market dispersion. Central bank liquidity policy can influence real and financial outcomes without materially impairing money-market functioning.

Taken together, our results imply that LOLR shocks identified through the haircuts applied to the collateral provided by banks have economically meaningful and persistent effects on the macroeconomy. These effects operate through easier credit conditions, lower bank funding costs, and reduced systemic financial risk. At the same time, haircut policies are fundamentally distinct from conventional monetary policy: they generate opposite movements in the slope of the yield curve and leave money-market dispersion largely unaffected. They also exhibit markedly different timing in their financial transmission.

These findings support both positive and normative conclusions. On the positive side, they highlight the importance of jointly modeling LOLR and monetary policy shocks when evaluating the transmission and interaction of central bank instruments. On the normative side, our results suggest that—absent institutional constraints enforcing a strict separation of tasks—a central bank could, in principle, rely on two distinct policy levers, collateral haircuts and policy rates, rather than exclusively on the latter. The optimal joint design and deployment of these instruments remains an important question for future research.

8 Conclusions

This paper provides the first comprehensive empirical assessment of the macro-financial effects of LOLR shocks. Our analysis rests on two central contributions, both methodological and empirical in nature, which together advance the understanding of how central bank collateral policy transmits to the real and financial economy.

Methodologically, we develop a novel identification strategy that combines an instrument - the haircut gap - built using granular (security-level) data with narrative sign restrictions in a structural VAR framework, allowing us to isolate exogenous movements in collateral haircuts despite the endogeneity of the policy, the bilateral nature of central bank refinancing operations, and the absence of high-frequency market surprises. This approach improves the credibility of causal inference and offers a framework for studying other central bank tools with similar identification challenges.

Empirically, we trace the effects of LOLR haircut shocks not only on the macroeconomy, but also across bank funding conditions, credit markets, systemic risk, and money-market functioning. Our results reveal that easing haircuts expands credit to both firms and households, lowers lending rates, and broadly strengthens bank balance sheets without inducing credit reallocation. Haircut shocks also stabilize bank funding conditions: bank bond spreads fall, and systemic risk declines and remains below baseline persistently. Unlike conventional monetary policy, LOLR shocks have limited effects on money-market dispersion, highlighting their institutional distinctiveness.

These findings highlight that central bank liquidity policy is a first-order macro-financial tool, which can support credit and financial stability without altering the monetary policy stance. Central banks can deploy two distinct levers — the policy rate and the collateral framework — to stabilize the economy, raising important questions for optimal policy design

and welfare. More broadly, our framework opens the door to future research on collateral eligibility, valuation, and central bank risk management, offering a versatile toolkit for understanding the broader real and financial market implications of central bank interventions.

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Figure 1: Repurchase Agreement. (Ex. ECB's MRO, FED's Temporary OMOs)

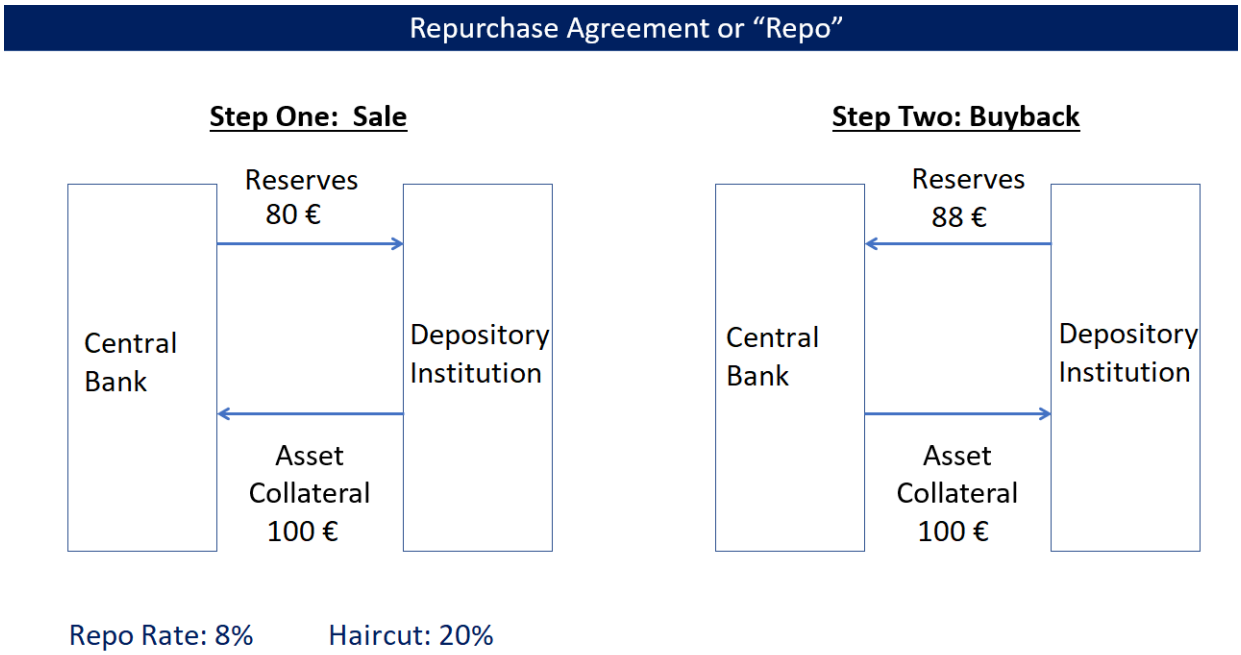
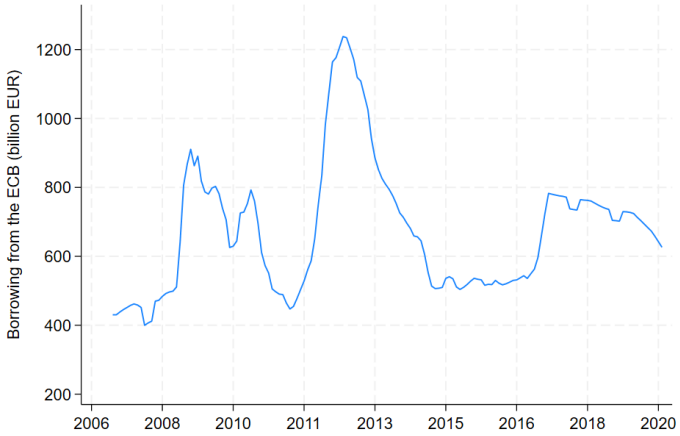


Figure 2: Central Bank Liquidity and Haircut Gap

(a) Borrowed Reserves from ECB



(b) Haircut Gap



(c) Haircut Gap Dispersion Across Banks

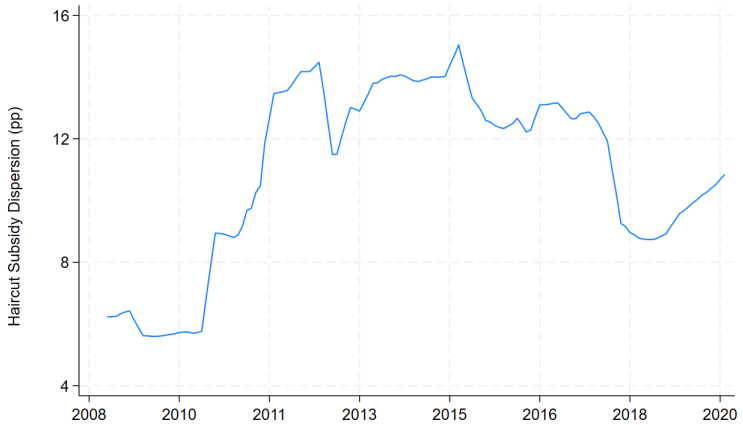


Table 1: Summary statistics

		N	mean	sd	p25	p50	p75
		(1)	(2)	(3)	(4)	(5)	(6)
ISIN-time sample							
Haircut Gap	percentage points	63,138	9.94	19.60	0.09	2.54	11.60
ECB haircut	in percent	63,082	4.91	4.56	1.50	4.00	7.50
Private market haircut	in percent	63,082	14.95	22.37	3.29	6.62	17.44
Value Pledged	% of value outstanding	63,167	19.80	31.60	0.84	4.72	19.90
Credit sample: bank-time							
Haircut Gap	% of total assets	7,612	0.2250	0.6620	0.0043	0.0297	0.1600
Security holdings	% of total assets	7,612	11.10	11.20	4.56	9.53	15.20
log(total assets)		7,612	10.71	1.61	9.69	10.70	11.90
log(loans to NFC)		7,612	8.68	1.84	7.72	9.09	9.88
log(loans to HH)		7,299	8.32	2.23	7.37	8.79	9.87
Capital ratio		7,612	0.08	0.10	0.04	0.07	0.10

Notes: This table show the summary statistics of key variables for the sample period Jan 2009 – March 2015.

Table 2: LOLR lending Effects: credit to the private sector

	$log\,(NFC\ credit_{b,t})$		$log\,(HH\ credit_{b,t})$	
	(1)	(2)	(3)	(4)
$\text{HaircutGap}_{b,t-1}$	0.0250***	0.0265***	0.0358**	0.0508***
	(0.00605)	(0.00850)	(0.0178)	(0.0175)
Time FE	Yes	No	Yes	No
Bank FE	Yes	Yes	Yes	Yes
Country × Time FE	No	Yes	No	Yes
N	7,612	7,612	7,154	7,154
R^2	0.997	0.998	0.998	0.999

Notes: This table presents coefficients from the credit regressions, as described in equation (3).The reported coefficients are standardized. Standard errors are clustered at the bank and time level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Lending to firms and households: core vs periphery

	$\log(\text{NFC credit}_{b,t})$						$\log(\text{HHcredit}_{b,t})$					
	Periphery		Core		All		Periphery		Core		All	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\text{HaircutGap}_{b,t-1}$	0.0151*	0.00280	0.0495**	0.0607***	0.00615	0.00255	0.0334***	0.0254*	0.0226**	0.0261***	0.0281***	0.0305**
	(0.00808)	(0.00763)	(0.0187)	(0.0160)	(0.00917)	(0.00955)	(0.00803)	(0.0134)	(0.00875)	(0.00958)	(0.00654)	(0.0120)
$\text{Core}_b \times \text{HaircutGap}_{b,t-1}$					0.0454***	0.0600***					-0.00655	-0.00878
					(0.0155)	(0.0172)					(0.00945)	(0.0140)
$(\text{Securities/TA})_{b,t-1}$	0.00192	-0.0389	0.0680	0.00970	0.00782	-0.0149	-0.0121	-0.0249	-0.0327	-0.0488	-0.0118	-0.0495
	(0.0146)	(0.0254)	(0.0706)	(0.0395)	(0.0153)	(0.0272)	(0.0128)	(0.0321)	(0.0556)	(0.0537)	(0.0124)	(0.0321)
Time FE	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country × Time FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
N	2,461	2,461	3,905	3,905	6,366	6,366	2,644	2,644	4,180	4,180	6,824	6,824
R^2	0.999	0.999	0.998	0.999	0.998	0.999	0.997	0.998	0.998	0.998	0.998	0.998

Notes: This table presents coefficients from the credit regressions, as described in equation (3). The reported coefficients are standardized. Standard errors are clustered at the bank and time level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: LOLR lending Effects: bank-level credit to the corporate sector

	$\log(\text{NFC credit}_{b,t})$			
	(1)	(2)	(3)	(4)
Haircut $\text{Gap}_{b,t-1}$	0.0250^{***}	0.0265^{***}		
	(0.00605)	(0.00850)		
Residual Haircut $\text{Gap}_{b,t-1}$			0.00792^{***}	0.00862^{***}
			(0.00225)	(0.00298)
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	No	Yes	No
Country-Time FE	No	Yes	No	Yes
N	7,612	7,612	7,612	7,612
R^2	0.997	0.998	0.996	0.997

Notes: This table presents coefficients from the credit regressions, as described in equation (3). The reported coefficients are standardized. Standard errors are clustered at the bank and time level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: LOLR lending Effects: loan-level evidence

	log(NFC new credit$_{f,b,t}$)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Haircut Gap$_{b,t-1}$	0.0579***	0.0847***	0.0634***	0.141***				
	(0.0125)	(0.0142)	(0.0194)	(0.0461)				
Residual Haircut Gap$_{b,t-1}$					0.0575***	0.0471***	0.0914***	0.0912***
					(0.00624)	(0.00705)	(0.0113)	(0.0275)
Bank FE	Yes	No	Yes	No	Yes	No	Yes	No
Firm FE	Yes	No	No	No	Yes	No	No	No
Bank-Firm FE	No	Yes	No	Yes	No	Yes	No	Yes
Country x Sector x Time FE	Yes	Yes	No	No	Yes	Yes	No	No
Firm-Time FE	No	No	Yes	Yes	No	No	Yes	Yes
N	265752	218440	50258	9434	247690	203407	47745	9102
r2	0.790	0.785	0.843	0.922	0.789	0.782	0.845	0.923

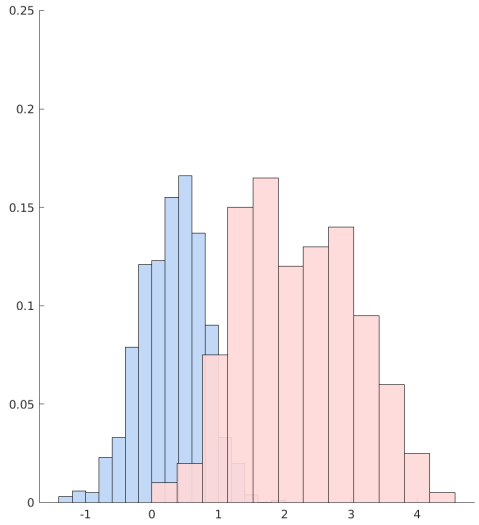
Notes: This table presents coefficients from the credit regressions, as described in equation (3). The reported coefficients are standardized. Standard errors are clustered at the bank and time level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 3: Residualized Haircut Gap - Information Variable

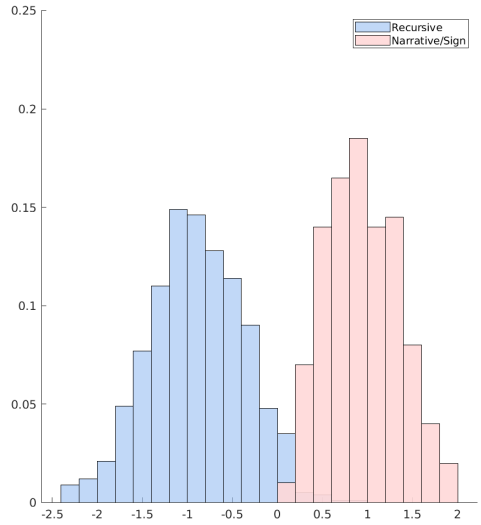


Figure 4: Shocks Distributions with Recursive vs Narrative & Sign identification schemes

(a) Shocks for January 2011



(b) Shocks for December 2011



(c) Shocks for June 2014

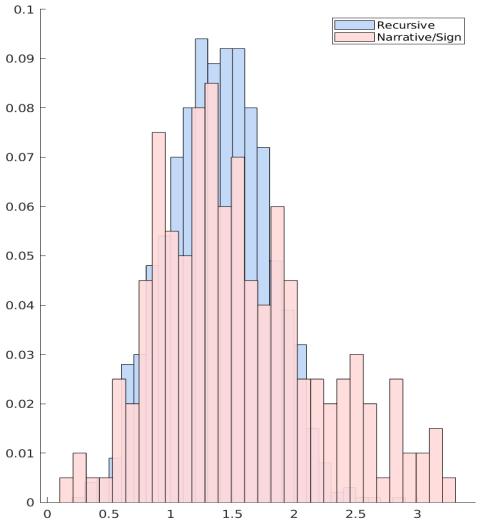
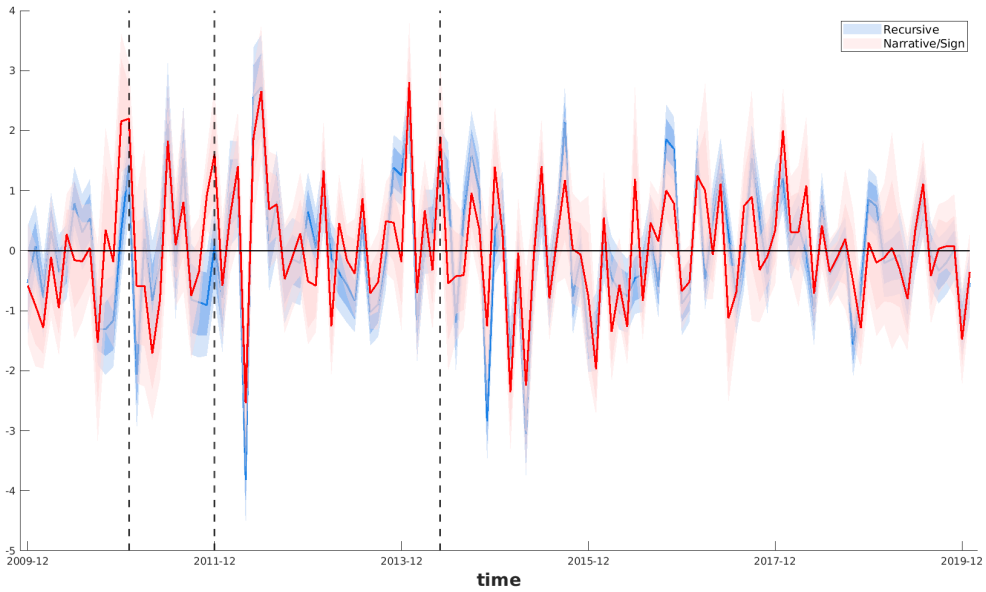
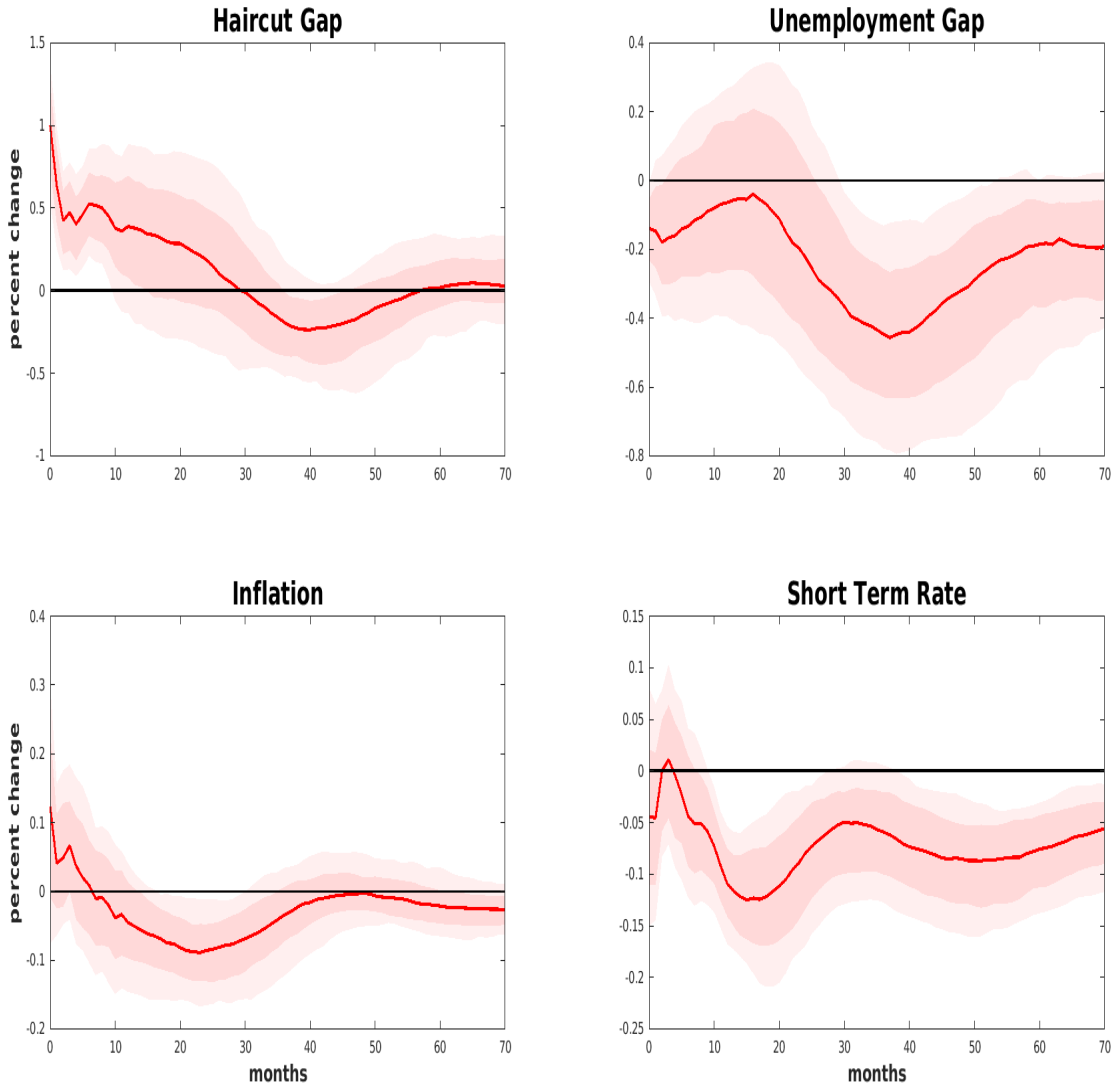


Figure 5: Haircut Shocks: Recursive vs Narrative Sign Restrictions



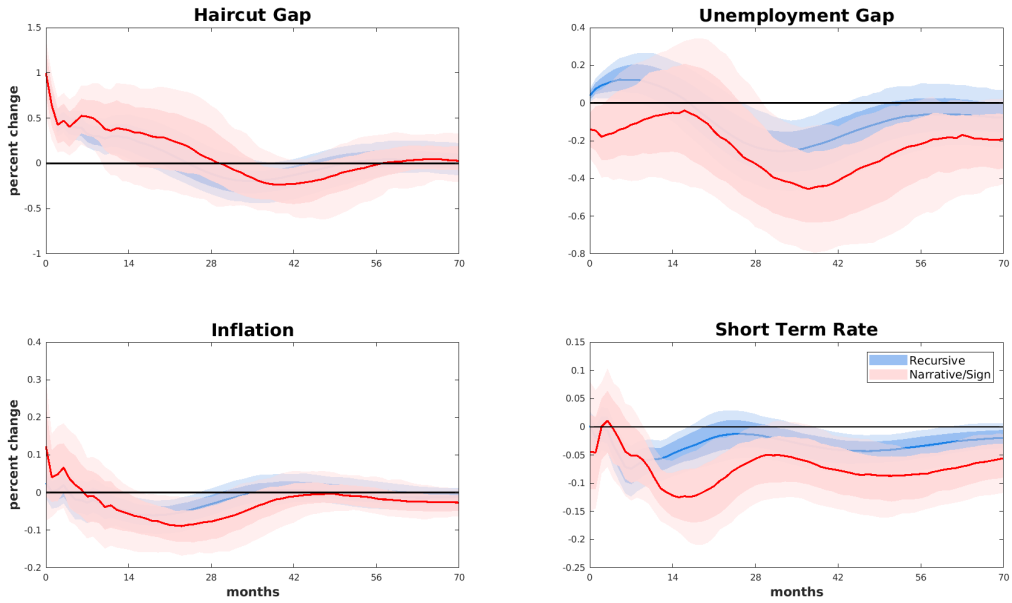
Notes: Time series of extracted shocks. Identification through Recursive (blue) and Narrative Sign Restrictions (red) as described in the main text. Sample 2009:M1-2020M2.

Figure 6: Haircut Shock: Baseline Specification



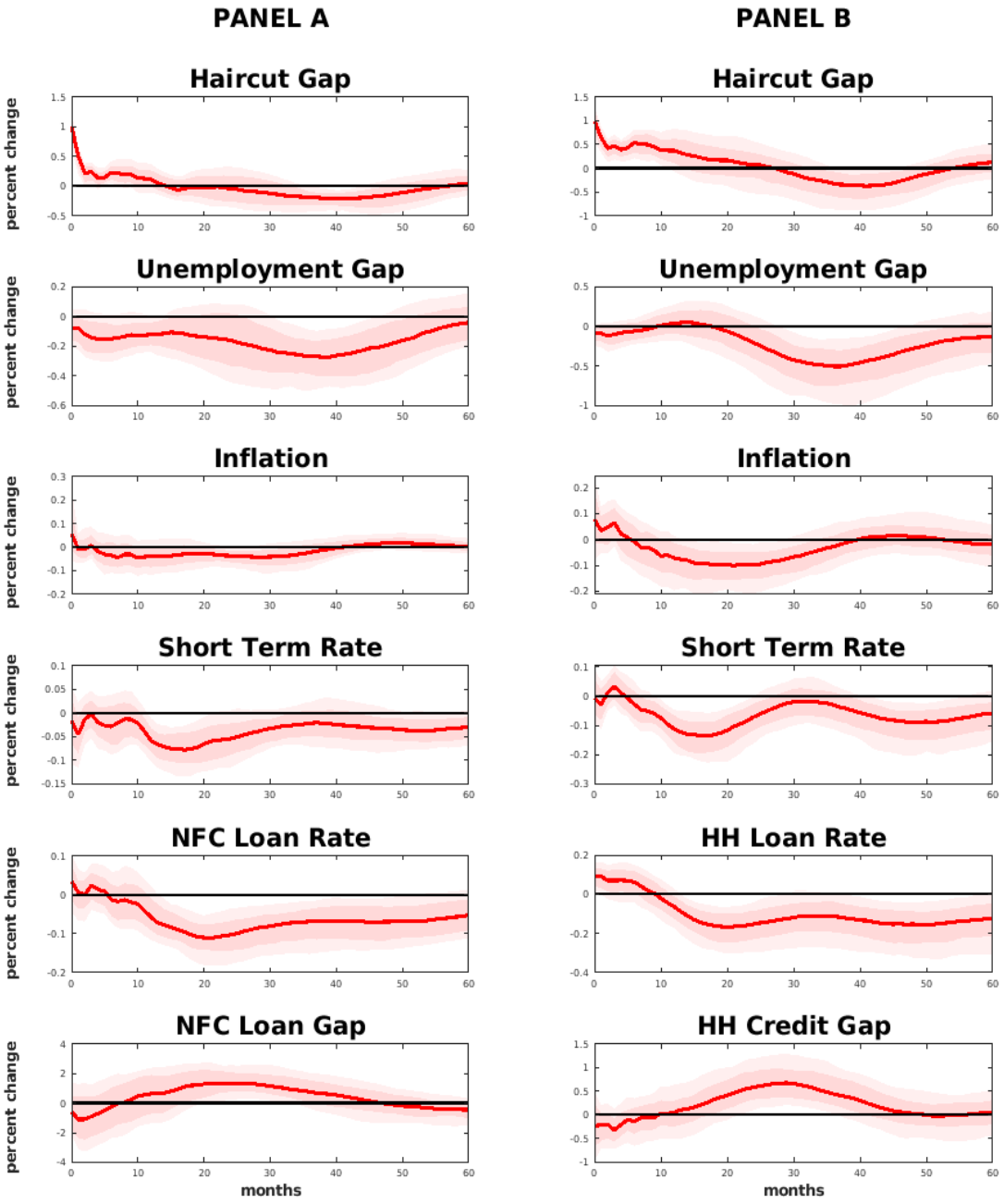
Notes: Impulse Response Function to a 1 percentage point Haircut Gap Shock. Bayesian VAR model. Identification through Narrative Sign Restrictions on the Haircut Gap Variable as described in the main text. Sample 2009:M1-2020M2.

Figure 7: Haircut Shocks: Recursive vs Narrative Sign Restrictions



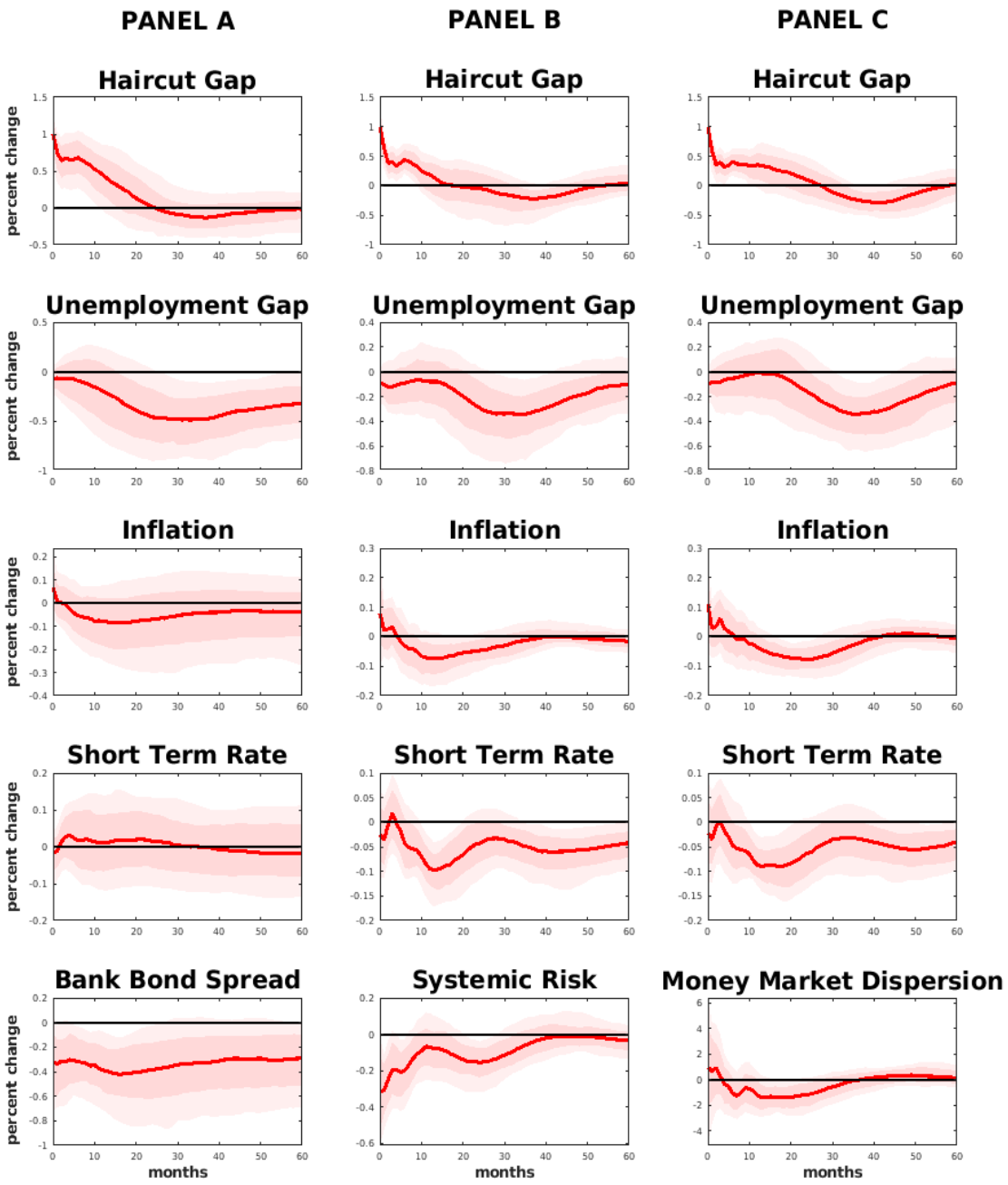
Notes: Impulse Response Functions. Identification through Recursive (blue) and Narrative Sign Restrictions (red) as described in the main text. Sample 2009:M1-2020M2.

Figure 8: Haircut Shock: NFC and Household Credit



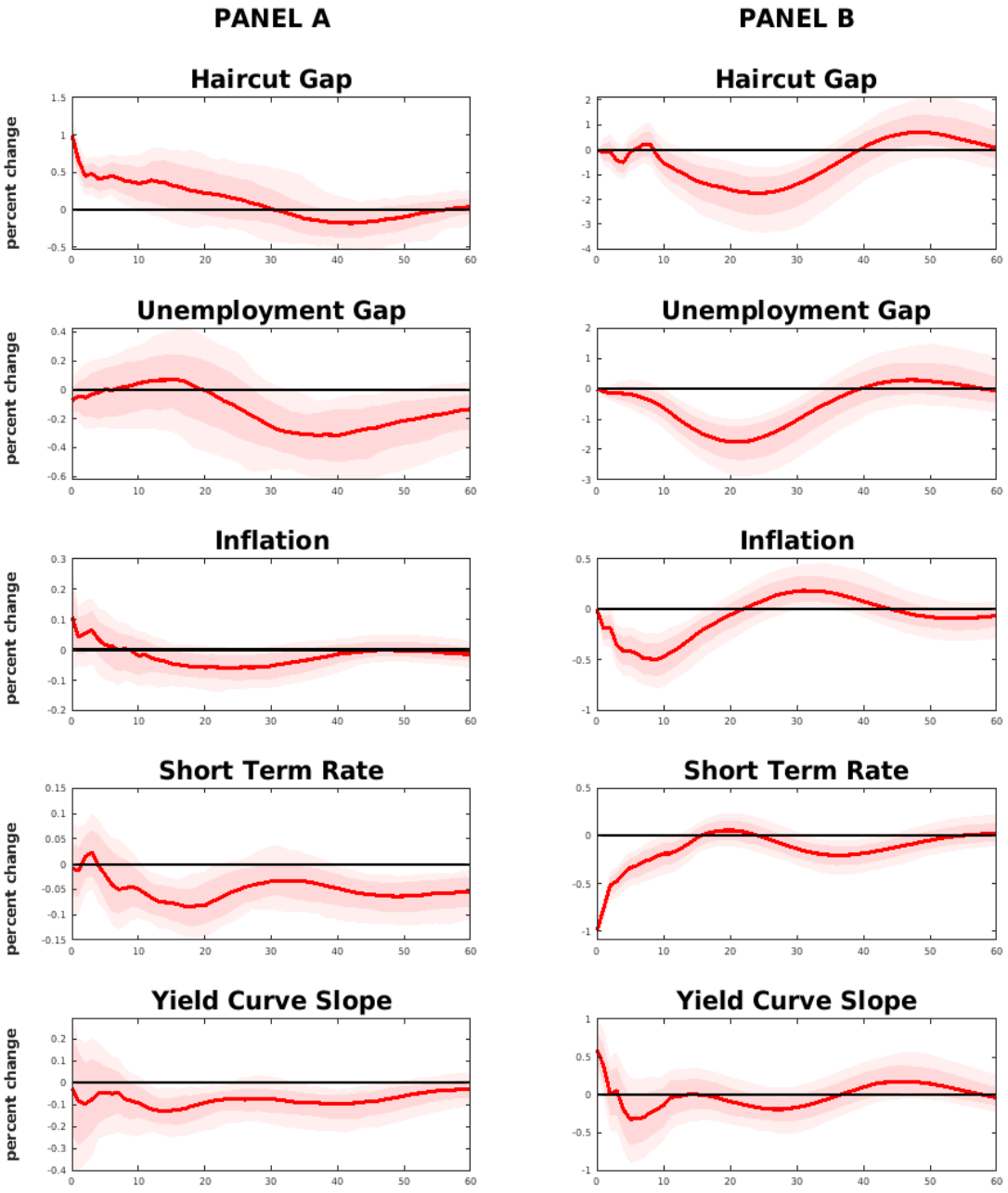
Notes: Impulse Response Function to a 1 percentage point Haircut Gap Shock. Bayesian VAR model. Identification through Narrative Sign Restrictions on the Haircut Gap Variable as described in the main text. Sample 2009:M1-2020M2. Panel A extends the baseline specification by adding the average EA NFC on New Loans and the NFC Credit Gap. Panel B extends the baseline specification by adding the average EA Household on New Loans and the Household Credit Gap.

Figure 9: Haircut Shock: impact on financial market indicators



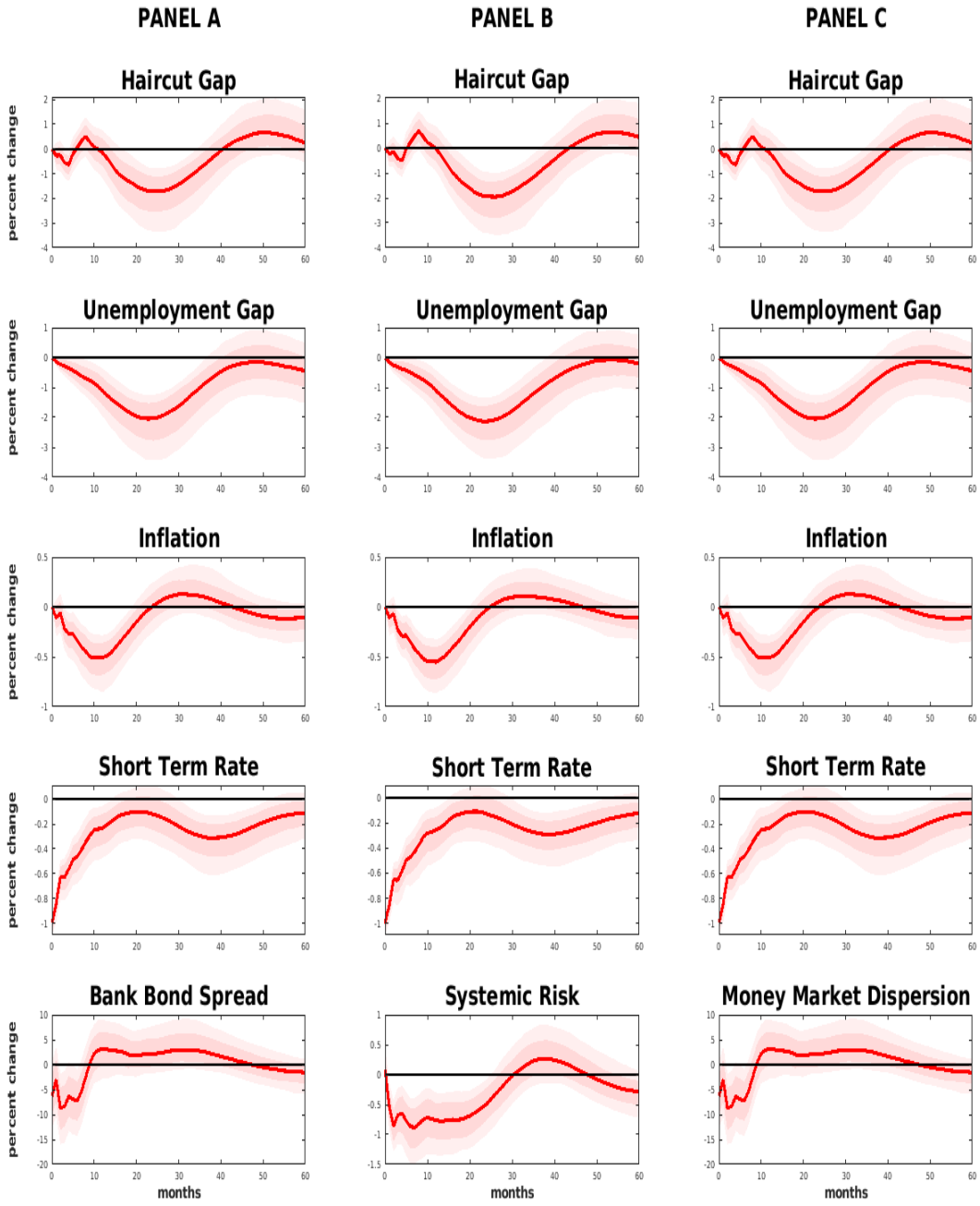
Notes: Impulse Response Function to a 1 percentage point Haircut Gap Shock. Bayesian VAR model. Identification through Narrative Sign Restrictions on the Haircut Gap Variable as described in the main text. Sample 2009:M1-2020M2. Panel A extends the baseline specification by adding the average EA NFC on New Loans and the NFC Credit Gap. Panel B extends the baseline specification by adding the average EA Household on New Loans and the Household Credit Gap.

Figure 10: Haircut Shock Vs Monetary Policy, Yield Curve



Notes: Impulse Response Function to a 1 percentage point Haircut Gap Shock. Bayesian VAR model. Identification through Narrative Sign Restrictions on the Haircut Gap Variable as described in the main text. Sample 2009:M1-2020M2. Panel A extends the baseline specification by adding the average EA NFC on New Loans and the NFC Credit Gap. Panel B extends the baseline specification by adding the average EA Household on New Loans and the Household Credit Gap.

Figure 11: Monetary Policy Shock: impact on financial market indicators

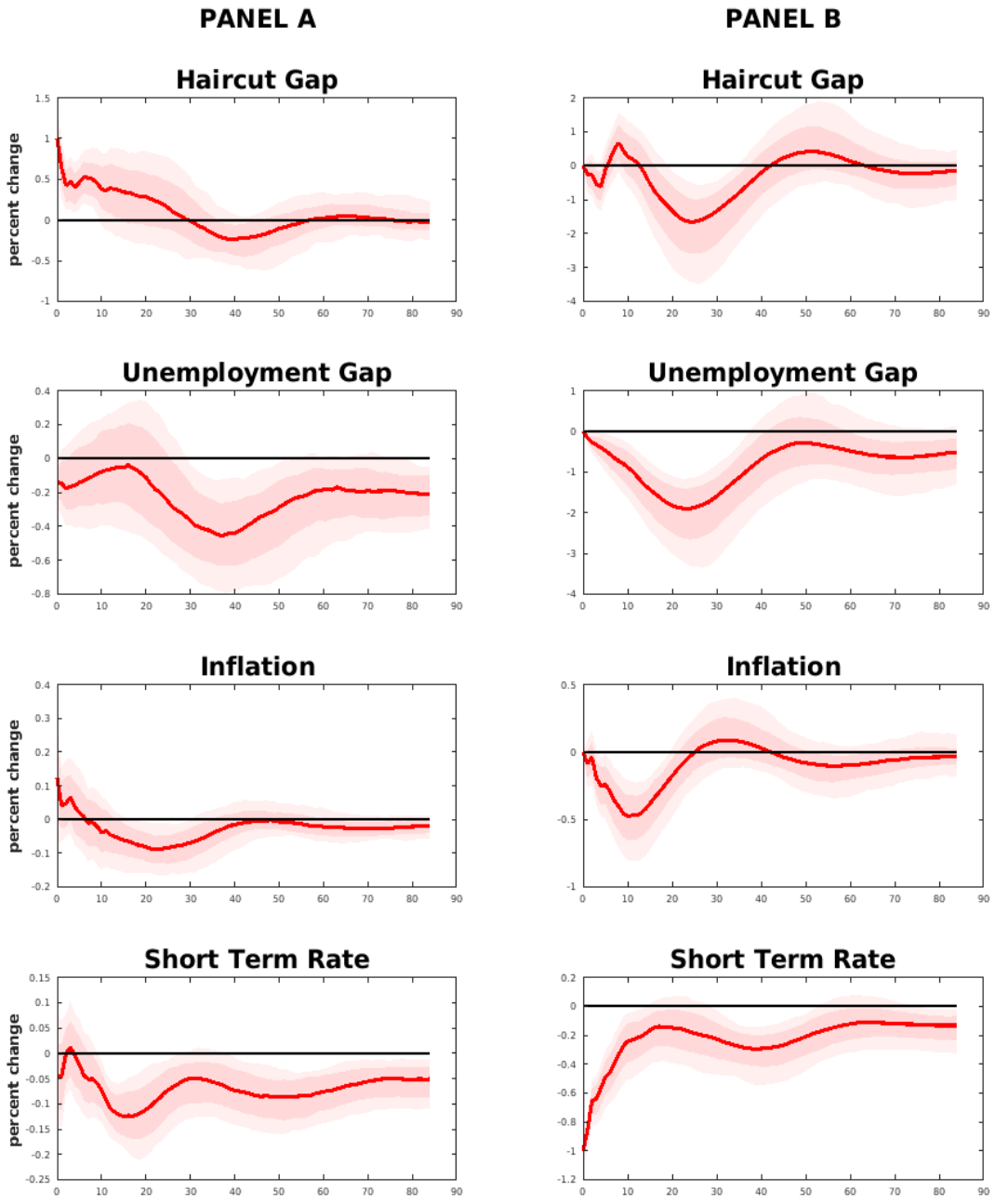


Notes: Impulse Response Function to a 1 percentage point Haircut Gap Shock. Bayesian VAR model. Identification through Narrative Sign Restrictions on the Haircut Gap Variable as described in the main text. Sample 2009:M1-2020M2. Panel A extends the baseline specification by adding the average EA NFC on New Loans and the NFC Credit Gap. Panel B extends the baseline specification by adding the average EA Household on New Loans and the Household Credit Gap.

"Beyond Policy Rates: Macroeconomic Effects of Lender-of-Last-Resort Shocks"

A Additional Results

Figure B1: Haircut Shock Vs Monetary Policy, Baseline



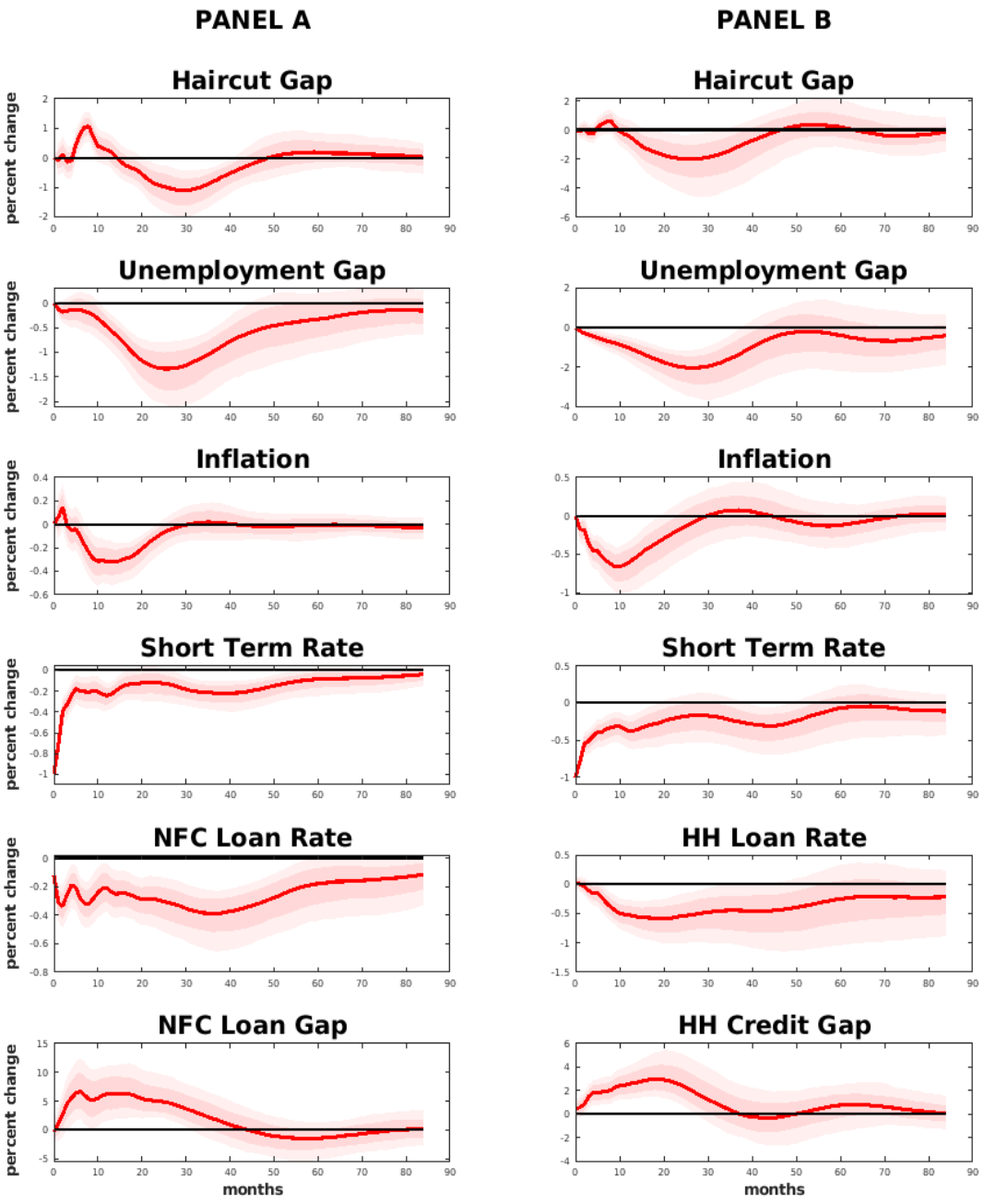
Notes: Impulse Response Function to a 1 percentage point Haircut Gap Shock. Bayesian VAR model. Identification through Narrative Sign Restrictions on the Haircut Gap Variable as described in the main text. Sample 2009:M1-2020M2. Panel A extends the baseline specification by adding the average EA NFC on New Loans and the NFC Credit Gap. Panel B extends the baseline specification by adding the average EA Household on New Loans and the Household Credit Gap.

Figure B2: Monetary Policy Shock



Notes: Impulse Response Function to a 1 percentage point Haircut Gap Shock. Bayesian VAR model. Identification through Narrative Sign Restrictions on the Haircut Gap Variable as described in the main text. Sample 2009:M1-2020M2. Panel A extends the baseline specification by adding the average EA NFC on New Loans and the NFC Credit Gap. Panel B extends the baseline specification by adding the average EA Household on New Loans and the Household Credit Gap.

Figure B3: Monetary Policy Shock, NFC and HH Credit



Notes: Impulse Response Function to a 1 percentage point Haircut Gap Shock. Bayesian VAR model. Identification through Narrative Sign Restrictions on the Haircut Gap Variable as described in the main text. Sample 2009:M1-2020M2. Panel A extends the baseline specification by adding the average EA NFC on New Loans and the NFC Credit Gap. Panel B extends the baseline specification by adding the average EA Household on New Loans and the Household Credit Gap.