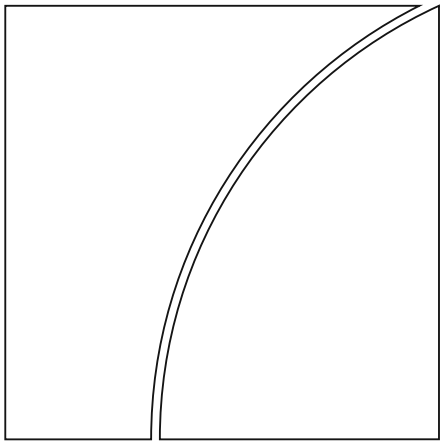

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The Liquidity Coverage Ratio a decade on: a stocktake of the literature

Sebastian Doerr and Mathias Drehmann[1]

Abstract

In the decade since the implementation of the Liquidity Coverage Ratio (LCR), what have we learned about its design, effectiveness and impact? The LCR is a central pillar of the Basel III regulatory reforms and aims to ensure that banks hold sufficient high-quality liquid assets to withstand short-term funding stress. Theoretical work, which mostly features fire-sale externalities, concludes that the LCR can raise welfare by mandating banks to hold more liquid assets or rely less on fragile short-term funding. Empirical work suggests that the LCR strongly raises banks' high-quality liquid assets and somewhat reduces their reliance on short-term funding. However, it can crowd out lending and induce greater risk-taking. The survey concludes with a discussion of open questions about the LCR's effectiveness, design and interaction with central bank policies.

Keywords: Basel III, liquidity coverage ratio, liquidity regulation, HQLA, deposits, systemic risk.

JEL classification: G20, G21, G28.

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Contents

1. Introduction

Liquidity risk is part and parcel of banking, as banks fund long-term, illiquid assets with short-term, demandable liabilities. While this liquidity creation serves the real economy, it exposes banks to runs and the economy to the risk of financial crises. The Great Financial Crisis (GFC) of 2007–09 and the banking turmoil of 2023 have exemplified the costs of liquidity crises for banks, the financial system and the economy.

In response to the GFC, Basel III introduced the first global regulatory framework covering liquidity risk. The key metrics are the Liquidity Coverage Ratio (LCR) – the focus of this article – and the Net Stable Funding Ratio (NSFR). The LCR was finalised in 2010 and phased in from 2015 to 2019.

The narrow objective of the LCR is to buy regulators and supervisors time during stress episodes. In particular, the stock of unencumbered high-quality liquid assets (HQLA) "should enable the bank to survive until Day 30 of the stress scenario, by which time it is assumed that appropriate corrective actions can be taken by management and supervisors, or that the bank can be resolved in an orderly way" (BCBS (2013)). The LCR's main objective is embedded in a broader discussion about the systemic implications of liquidity risk. Fire sales could undermine confidence in troubled banks and cause mark-to-market losses for other banks holding similar assets, thereby "encouraging further fire sales and declines in prices and market liquidity" (BCBS (2013)).

But what do we know about the design and effectiveness of liquidity regulation and the LCR in particular? According to Diamond and Kashyap (2016) "practice is far ahead of both theory and measurement", while Allen and Gale (2017) lament that "with capital regulation there is a huge literature but […] with liquidity regulation we do not even know what to argue about". A decade after the introduction of the LCR, is this still the state of our knowledge?

This paper surveys the theoretical and empirical literature about the LCR, highlighting key findings and gaps. We concentrate on the LCR because it focuses on short-term resilience to immediate liquidity stress, while the NSFR targets long-term funding stability by aligning asset maturities with durable funding sources. The survey examines the following main questions: How do the design, objectives and intended consequences of the LCR compare with insights from the literature? What have we learned about the effects of the LCR on bank behaviour? And which questions remain unanswered?

While the literature on liquidity risk in banking is large, theoretical work on liquidity regulation is limited. In general, existing work clarifies the welfare implications of LCR-type rules. The vast majority of papers feature fire-sale externalities as the key friction, so that banks rely too much on short-term debt or invest too much in illiquid assets from a social planner's point of view. Papers typically find that a Pigouvian tax would be optimal to address the distortion. It could be implemented via a fee for a committed liquidity facility at the central bank. But LCR-style requirements are also welfare-improving by mandating banks to hold more liquid assets or rely less on fragile short-term funding. The LCR is particularly effective when regulators lack the information to design the optimal Pigouvian tax. Another general finding is that capital and liquidity regulation are complements.

One contribution abstracts from fire-sale externalities to examine the regulation's explicit goal of "buying time". It shows that, by slowing runs, a liquidity buffer allows the lender of last resort (or supervisors more broadly) to distinguish illiquid but solvent banks from insolvent ones, reducing inefficient liquidations.

All in all, theoretical results suggest that, in the presence of fire-sale externalities, having a form of liquidity regulation is welfare-enhancing, even in cases where the design is second best. However, models often highlight trade-offs: higher liquidity buffers may crowd out productive lending and induce greater risk-taking by banks and/or a migration of risks towards less-regulated intermediaries.

The empirical literature assessing the impact of the LCR is broadly consistent with the theoretical predictions. It yields three main insights. First, banks typically comply with the LCR by increasing their HQLA holdings, in particular through higher reserve and government bond holdings. Balance sheet shrinkage is rare, but banks tend to cut back their credit supply to households and firms as liquid assets displace loans, resulting in lower bank profitability. Second, funding structures adjust, but to a much smaller extent than assets: short-term wholesale liabilities contract, while retail deposits and longer-maturity sources expand somewhat. Third, liquidity regulation, by lowering bank profits, can lead to increases in banks' asset opacity or shifts into harder-to-value and riskier assets.

Liquidity risks may also migrate to less-regulated entities. Overall, the empirical evidence suggests that the LCR changes bank assets and liabilities as intended, but the side effects may blunt its benefits.

Despite these advances, important questions about the LCR's calibration, impact, cyclicality and interactions with central bank tools remain unanswered. There is a lack of consensus on the appropriate calibration of deposit run-off rates in a world of digital banking and large operational deposits. The extent to which liquidity regulation has curtailed credit supply to the real economy or fuelled the growth of non-bank financial institutions (NBFIs) also remains an open question. As well, we do not know whether liquidity regulation has bolstered banks' resilience during crises. From a conceptual perspective, there is a tension between the goals of liquidity regulation, which are often macroprudential in nature, and the design of the LCR, which is a microprudential tool. Further unanswered questions relate to banks' ability to use their liquidity buffers during crises and the interaction of liquidity regulation with central bank policies.

The rest of the paper is structured as follows. Section 2 provides a brief history of liquidity regulation in the Basel process and then describes the design and goals of the LCR. Section 3 discusses theoretical and empirical work on the design and consequences of the LCR. Finally, section 4 highlights gaps in our knowledge and outlines areas for future research.

2. The design and goals of the LCR

Liquidity has been on the agenda of the Basel Committee on Banking Supervision (BCBS) from the outset. The first Chairman of the BCBS, George Blunden, opened the inaugural meeting in 1974 by stating that "the Committee's main objective was to help ensure banks' solvency and liquidity" (quoted from Goodhart (2011)). But progress was slow initially. Only in 1992 did the Committee codify prevailing bank

practices on managing liquidity risks into an analytical toolkit, to anchor discussions between supervisors and internationally active banks. By 2000, wholesale funding rivalled core deposits as a primary funding source, prompting an update in the form of 14 voluntary principles.[2]

During the GFC, wholesale funding markets froze and even well-capitalised banks suffered from liquidity shortages, laying bare the limits of voluntary guidance. In response, the 2010 *Basel III: International framework for liquidity risk measurement, standards and monitoring* introduced the LCR and the NSFR. The LCR aims to ensure that banks can survive a 30-day stress episode. The NSFR aims to address maturity mismatches beyond the one-year horizon (BCBS (2010)). A revised text issued in January 2013 fine-tuned the calibration and introduced a gradual rollout between 2015 and January 2019 to ensure an orderly transition (BCBS (2013)).

The 2023 banking turmoil, however, prompted the BCBS to re-examine liquidity regulation. While the designs of the NSFR and LCR were in large part motivated and shaped by the dry-up of wholesale short-term funding markets during the GFC, the 2023 bank failures showed that uninsured deposit runs can be equally devastating and that many HQLA were already encumbered for intraday or operational needs. In response, the Basel Committee has launched analytical work to re-examine the assumptions underpinning the LCR and liquidity regulation more broadly (BCBS (2023, 2024)).[3]

This survey examines what we know about liquidity regulation and its effectiveness during episodes of acute funding stress and run dynamics. Accordingly, we focus on the LCR, which explicitly targets stress episodes, and not the NSFR, whose one-year horizon addresses structural funding stability rather than liquidity at times of crisis.

2.1 The design of the LCR

The LCR requires, absent a situation of financial stress, the ratio of an institution's stock of HQLA to its projected net cash outflows over the next 30 calendar days to exceed 100%:

$$LCR = \frac{Stock\ of\ HQLA}{Total\ net\ cash\ outflows\ over\ 30\ days} \geq 100\%$$

For the numerator, only assets that demonstrably retain value and marketability in periods of strain qualify for the buffer. There are two categories. *Level 1 assets* carry no haircut and may make up 100% of the stock of HQLA. These include cash, central bank reserves and highly rated sovereign or central bank securities. *Level 2 assets* are subdivided into Level 2A assets (for example, certain high-grade public sector or covered bonds) and, at national discretion, Level 2B assets (for example, lower-rated corporate debt or equities in major indices). Level 2 holdings are subject to mandatory

[2] In 1992, the BCBS issued *A framework for measuring and managing liquidity* and in 2000 *Sound practices for managing liquidity in banking organisations*. A further update was issued in 2008 with the *Principles for sound liquidity risk management and supervision*.

[3] The Financial Stability Board (FSB) has performed complementary analyses (FSB (2024)).

haircuts of at least 15% (Level 2A) or 25–50% (Level 2B) and together may not exceed 40% of the total stock, with Level 2B capped at 15%.

Assets also need to meet operational requirements. Holdings must be unencumbered, centrally controlled by the liquidity management function and readily monetisable, by sale or repo, within standard settlement periods. To ensure that assets are indeed monetisable, banks should conduct regular "dry runs" to test market access and internal processes.

For the denominator, projected net outflows are calculated under a 30-day stress scenario. The calculation is rather detailed, but the idea underpinning it is straightforward. Net outflows are the difference between total expected cash outflows and total expected cash inflows. Total expected cash outflows are calculated by multiplying the outstanding balances of various categories or types of liabilities and off-balance sheet commitments by a run-off rate. For instance, retail deposits are assumed to run off at rates of 3–10% depending on stability; unsecured wholesale funding faces run-off rates of 25–100%; and committed but undrawn credit and liquidity facilities can generate outflows of up to 100%. Total expected cash inflows are calculated by multiplying the outstanding balances of various categories of contractual receivables by the rates at which they are expected to flow in under the scenario up to an aggregate cap of 75% of total expected cash outflows.

The run-off rates driving net outflows are calibrated based on a stress scenario similar to the GFC. The scenario "incorporates many of the shocks experienced during the crisis that started in 2007 into one significant stress scenario" (BCBS (2013)). Under a combined idiosyncratic and market-wide shock, the scenario assumes: the run-off of a proportion of retail deposits; a partial loss of unsecured wholesale funding capacity; a partial loss of secured, short-term financing with certain collateral and counterparties; contractual outflows that would arise from a downgrade in the bank's public credit rating by up to and including three notches; increased margin requirements because of increases in market volatilities; unscheduled draws on committed credit and liquidity facilities; and the potential need for the bank to buy back debt or honour non-contractual obligations in the interest of mitigating reputational risk.

It is also important to note that the LCR is designed as a buffer rather than a minimum requirement that must always hold. During a period of financial stress, the rules allow banks to use their stock of HQLA, even if this would mean that the LCR falls below 100%. Conceptually, this avoids Goodhart's last taxi problem.[4]

2.2 Goals of the LCR

The LCR's core objective is to buy time in stress episodes. The backdrop is Bagehot's rule that dictates that a lender of last resort should "lend freely, at a penalty rate, against good collateral, but only to solvent institutions". In other words, solvent but illiquid banks should receive emergency liquidity to prevent inefficient runs and fire sales; insolvent banks should be resolved or recapitalised and not propped up with central bank credit. However, the challenge for policymakers is to figure out whether

[4] "A liquidity requirement is an oxymoron. If you have to continue to hold an asset to meet a requirement, it is not liquid. What is needed is a buffer, not a minimum requirement. There is a story of a traveller arriving at a station late at night, who is overjoyed to see one taxi remaining. She hails it, only for the taxi driver to respond that he cannot help her, since local bye-laws require one taxi to be present at the station at all times!" (Goodhart (2010)).

a bank is merely illiquid or actually insolvent. This requires a detailed understanding of a bank's asset allocation and underlying loan and security portfolio. The official documents thus emphasise that the 30-day horizon is intended to give bank management and supervisors "additional time to take appropriate corrective actions or to implement an orderly resolution" and give "the central bank additional time to take appropriate measures" (BCBS (2013)).

Another objective that is often mentioned in the context of the LCR is to prevent fire-sale dynamics and contagion during liquidity crises. As the official documents explain, if a bank under stress had to sell lower-quality assets, it would likely incur "a large fire-sale discount or haircut". This would undermine confidence in the bank and cause mark-to-market losses for other banks holding similar assets, thereby "encouraging further fire sales and declines in prices and market liquidity" (BCBS (2013)). The idea is that by holding sufficient highly liquid assets, banks can raise cash without triggering steep discounts and without fire-selling assets in a way that fuels market panic. If so, the LCR would avoid liquidity problems from snowballing into system-wide crises, thereby forestalling the need for emergency asset liquidations and breaking the chain of contagion that can arise from correlated fire sales.

It is important to note, however, that the official documents do not mention prevention of fire sales and contagion as an explicit goal of the LCR. The documents discuss the issue of fire sales only in the context of establishing whether liquid assets are of high quality, ie whether they can be readily converted into cash under severe stress in private markets. Section 4 revisits this question and discusses the tension between micro- and macroprudential goals.

3. Insights from research

A large literature has examined the role and provision of liquidity for financial intermediation and fragility.[5] However, studies on the design and implications of the LCR remain relatively scarce. In what follows, we first discuss theoretical papers that study to what extent the design of the LCR is efficient and how it compares with alternative approaches to liquidity regulation. We then review work that has assessed empirically the effects of the LCR (or comparable liquidity regulation) on banks, financial stability and the real economy.

3.1 Theoretical work on the LCR

Theoretical work on the LCR in general concludes that liquidity regulation is welfare-enhancing in the presence of fire-sale externalities, even if the current design is not optimal. Moreover, it finds that capital and liquidity regulation are often complements. The vast majority of papers feature fire-sale externalities as the key friction to motivate liquidity regulation. The LCR's explicit goal to buy time for regulators usually plays no role in the model setups.

In an early contribution, Perotti and Suarez (2011) study the welfare implications of different approaches to liquidity regulation. The trade-off at the heart of the paper is that banks can finance profitable credit expansions only with short-term debt.

[5] Among others, Allen and Gale (2017), De Nicolo (2016) and Diamond and Kashyap (2016) survey the literature on liquidity and the rationale for regulation or central bank policies to address liquidity risks.

Higher short-term debt, in turn, increases the expected costs of a systemic crisis, which banks do not fully internalise. The setup is motivated by fire-sale externalities but abstracts from potential contagion effects.

Perotti and Suarez show that the efficiency of LCR-type quantity-based regulation versus price-based regulation via a Pigouvian tax depends on the characteristics of the banking system. When banks differ in their productivity (some banks earn higher marginal returns from making the same loan, for example, because they are better at screening and monitoring), the LCR is distortionary, while a tax is efficient. The intuition is that quantity-based regulation is more binding for productive banks, which leads to misallocation. When banks have the same productivity but differ in their risk-shifting incentives (for example because of low charter value), quantity-based regulation is more efficient. Under price-based regulation, risk-loving banks would still be willing to pay the higher price for short-term funding to gamble for resurrection. If banks differ along both dimensions, a mix of quantity- and price-based regulation is adequate.[6]

Walther (2016) studies the effectiveness of liquidity regulation in a setting in which competitive banks choose their investments, maturity structure and cash reserves prior to aggregate and idiosyncratic shocks. Short-term debt is attractive for banks because creditors require a liquidity-preference premium on longer maturities, but it exposes banks to a collateral (haircut) constraint at rollover. When many institutions receive negative shocks simultaneously and liquidate assets to satisfy this constraint, a pecuniary fire-sale externality pushes prices below fundamentals. Individual banks do not internalise this effect and thus rely excessively on short-term debt.

The paper shows that the LCR increases welfare. By forcing banks to effectively pre-fund part of their runnable debt, it lowers the incidence of collateral-driven fire sales, increases the probability that projects are rolled over rather than liquidated and raises the private cost of pursuing higher ex ante leverage or maturity mismatch. Because the requirement relies solely on observables, it outperforms a Pigouvian levy on short-term debt when supervisors lack precise information about banks' investment technologies.

Sundaresan and Xiao (2024) use a structural model to contrast liquidity regulation via the LCR (a "quantity-based rule") with a committed liquidity facility at the central bank (a "price-based rule"). Early liquidation of assets imposes an externality on society. As in Perotti and Suarez (2011), this aims to capture fire-sale externalities that banks do not internalise. Hence, they do not hold enough liquidity buffers and issue too much short-term debt, necessitating liquidity regulation.[7]

Calibrating the model to US data, the authors find that the LCR increases welfare by acting as an implicit tax that forces banks to internalise the externality. But it cannot achieve the first-best solution, as the LCR faces a trade-off between achieving optimal liquidity versus lending and can lead to migration of lending activity to unregulated

[6] These considerations abstract from capital regulation. The authors conclude that when the regulator can address risk shifting via capital regulation, a Pigouvian tax is generally preferred over quantity-based regulation.

[7] The model features an endogenous liquidity premium, where a higher liquidity premium lowers the return of the illiquid assets but also lowers the cost of short-term funding. In the presence of a fire-sale externality, the liquidity premium is excessively high and thus reduces the cost of short-term funding to the extent that banks use too much of it. An LCR-like requirement lowers the liquidity premium and thereby banks' reliance on short-term debt. However, it also increases the relative return of liquid assets, which crowds out productive lending.

entities. In contrast, the first-best can be obtained by taxing the fire-sale externality via a Pigouvian tax. This can be implemented via a committed liquidity facility from the central bank, which banks can access in times of stress, but for which they have to pay a fee in normal times.[8] The fee acts as the Pigouvian tax, but the unused liquidity commitments do not occupy balance sheet space and thus do not crowd out lending. The credit facility allows banks to purchase liquidity in states in which the liquidity premium is too high, but it does not require banks to have extensive liquid asset holdings in all states.

Fire-sale externalities and rollover frictions make liquidity and capital requirements complements, not substitutes. Kara and Ozsoy (2020) study the interaction of capital and liquidity regulation in the presence of fire-sale externalities. Liquidity risk arises from a need to inject additional cash into long-term assets in bad times, as in Holmström and Tirole (1998). Banks need to either hold cash up front or raise it ex post by selling some of the long-term assets at fire-sale prices, which decrease the aggregate volume of asset sales. As banks do not internalise fire-sale externalities, they overinvest in risky assets. Liquidity regulation, by forcing banks to hold more liquidity, can improve welfare. In the model, eliminating all fire sales through high liquidity requirements is not optimal, as there is a trade-off: holding liquidity is costly independent of the state but liquidity only has a positive benefit in the bad state when there are fire sales. Capital regulation without liquidity regulation is also not optimal, as banks respond by reducing their holdings of liquid assets. The reason is that the marginal value of liquidity declines with the level of financial stability, which in turn increases with the aggregate capital held by banks.

Complementing models with passive depositors, other contributions examine endogenous run dynamics. Applying global games techniques, these papers find that both capital and liquidity regulation are useful in increasing bank resilience, as the decision to run depends on both sides of the balance sheet.[9] Vives (2014) shows that capital regulation is more effective in controlling the probability of insolvency, whereas liquidity regulation is more effective in controlling the probability of a bank becoming illiquid but solvent. However, as König (2015) shows, liquidity regulation can also undermine a bank's expected solvency, as it forces banks to hold lower-yielding assets.

Building on this strand of the literature, Carletti et al (2020) endogenise banks' portfolio structure and analyse liquidity regulation. In a first step, the authors show that there is no role for liquidity regulation if there are no fire sales and the only frictions are strategic complementarities among depositors. In this case, capital requirements are the only effective tool to eliminate inefficient crises and achieve the socially optimal portfolio allocation between liquid and illiquid assets. In a second step, the model considers fire-sale externalities that increase with the total volume of long-term assets sold in the secondary market. Moreover, banks' fundamentals are correlated. Depositors' run decisions are then also affected by runs in other banks, which gives rise to contagion. As fire-sale externalities are not accounted for in banks' endogenous portfolio choices, banks hold too few liquidity buffers. In this setting, liquidity and capital requirements are again complements – liquidity regulation to manage the externalities arising from fire sales and capital regulation to manage the

[8] Bech and Keister (2014) also study the interaction between the LCR, a committed liquidity facility and the liquidity premium.

[9] Aldasoro and Faia (2016) also study contagion on both sides of balance sheet and use a model calibrated to European data to study the effects of phase-in increases of the LCR.

welfare losses arising from premature liquidation of profitable investments in states when the bank is solvent but illiquid.

Kashyap et al (2024) examine regulation in a model where banks create economic surplus for both borrowers and depositors but may choose a balance sheet that results in excessive run risk and an inefficient level of lending. They extend the classic Diamond-Dybvig framework. A monopolistic bank offers liquidity services to depositors, but also raises equity funding, makes risky loans and invests in safe, liquid assets. Banks must monitor borrowers, which is costly, so banks do so only if they get rewarded for it, giving rise to endogenous credit risk. Liquidity risk is endogenous, modelled via a global game. The run probability depends on the deposit contract (as this specifies returns to waiting), the bank's balance sheet (as this determines the capacity to service early withdrawals) and its profitability (given this determines its incentives to monitor). Run risk arises from choices on both sides of the bank's balance sheet. While the bank internalises how its choices affect run risk, deposit supply and loan demand, it does not internalise borrowers' and depositors' welfare. Hence, the private and social optimums diverge.

The model illustrates two important points. First is a trade-off for regulators. They can increase the safety of the bank via capital and liquidity regulation, which increases the welfare of savers. However, such regulation reduces bank profitability and thus monitoring, which restricts credit supply and the welfare of borrowers. The optimal choice of capital and liquidity regulation thus depends on how important borrowers and savers are to the planner. Second, combining capital and liquidity regulation can move the private solution closer to the planner's efficient outcome. Capital and liquidity regulations reduce run risk but restrict credit creation. Moreover, as banks take excessive risk on both sides of their balance sheet, controlling risk on one side may result in risk materialising on the other side. Capital and liquidity requirements are complementary, since they operate on different sides of the balance sheet.

Taken together, these papers typically conclude that capital and liquidity regulation are complements. Capital is more effective in containing insolvency risk, while liquidity requirements reduce rollover risk and fire-sale externalities by affecting the mix of assets that banks hold. Regulating both sides of the balance sheet therefore yields higher resilience than using either tool in isolation.[10]

Calomiris et al (2024) study the role of mandated cash buffers in mitigating liquidity risk in a model where short-term depositors act as disciplining device. Bankers use equity and demandable deposits to finance a portfolio of risk-free cash and risky loans. Risk management efforts are unobservable, giving rise to a moral hazard problem in the bad state when risk management is especially costly. Holding more cash attenuates this problem. More importantly, cash buffers are observable, so demandable deposits can act as a disciplining device to incentivise banks to increase cash holdings in bad states of the world.[11]

[10] These arguments are consistent with Admati et al (2013), who argue that because capital requirements refer to the mix between debt and equity on banks' balance sheets, while liquidity requirements relate to the type of assets and asset mix banks must hold, liquidity and capital requirements complement each other.

[11] The banker obtains a private benefit from "shirking" in the bad state, ie from not monitoring loans. When ex ante cash buffers are small, equity is wiped out in the bad state when some loans default, so the banker has a greater incentive to shirk. With higher (mandated) cash buffers, equity remains valuable even if some loans default. The banker thus has an incentive to monitor to maintain their equity claim.

There is a trade-off between raising cash ex ante and ex post: holding cash ex ante is costly because it has a lower return than loans, on average; raising cash ex post entails a fire-sale externality. The fire-sale externality also means that banks hold inefficiently low levels of cash ex ante. Liquidity requirements that prescribe a certain level of cash ex ante can therefore be welfare-improving, as they avoid the inefficient cost of fire sales. Moreover, they can incentivise bankers to exert greater effort on risk management in the bad state. The paper thus argues that liquidity requirements should focus on safe assets rather than the liability mix. Indeed, in the model, a greater presence of insured deposits with a lower withdrawal risk (which have low run-off rates in the LCR) undermine market discipline, as bankers hold less cash ex ante.

Beyond affecting banks' liquidity holdings and monitoring incentives, the LCR may also affect self-insurance through the interbank market, as shown in Erol and Ordonez (2017). While classic deposits from firms and households give rise to run risks, interbank deposits can be beneficial, as an interbank market allows banks to mutually insure against liquidity risks in some states of the world. This can give rise to trade-offs when the LCR is implemented. The authors develop a multi-bank environment in which institutions invest in productive projects yet face interim refinancing shocks. Banks endogenously form a network of credit lines that provide insurance across banks. Establishing a bilateral link entails a fixed management cost. A regulator imposes a liquidity requirement (modelled as reserves but interpretable as an LCR) at the individual bank level.

Tightening the LCR requirement initially yields a smooth, direct gain in the form of larger on-balance sheet buffers, but beyond a certain point, this leads to a collapse of the interbank network. The marginal benefit of a link declines with higher liquidity buffers. Hence, at some point marginal benefits fall below the fixed cost, and many connections are severed. With fewer links, there is iterative contagion: fewer neighbours means that one failure deprives other banks of refinancing, so liquidations or failures cascade. This increases systemic risk even though individual liquidity is higher. The optimal design of the LCR should therefore take into account not only bank-specific effects but also its effect on the interbank network.[12]

The papers discussed so far take a macroprudential perspective. They do not model the main objective of the LCR, nor do they consider a role for the central bank. When a lender of last resort is considered, an ex ante LCR and ex post liquidity injections are complements.

Santos and Suarez (2019) focus on the explicit goal of the LCR to buy time when there is a lender of last resort (LOLR). In their model, banks are funded with equity and short-term debt, which needs to be rolled over every period and introduces the possibility of a run. On the asset side, banks allocate their funds between more profitable illiquid and less profitable liquid assets. Banks may suffer from a shock in which illiquid assets may or may not get damaged and investors start to withdraw their funds.

When there is a shock, the LOLR needs time to assess the true quality of a bank's assets, ie to learn whether a bank is illiquid or insolvent. Liquidity regulation, by providing the LOLR with more time until the bank runs out of liquid assets to repay

[12] Beyond network tipping points, Malherbe (2014) shows how adverse selection dynamics can imply another non-linearity: tighter liquidity requirements, by reducing the need to sell assets in stress episodes, can impair market liquidity and induce a liquidity dry-up. This cautions against calibrations that ignore how the LCR may reshape secondary-market participation.

debtors, allows the regulator to acquire more valuable information and avoid inefficient liquidation (of illiquid but solvent banks) or inefficient support (of insolvent banks). Moreover, if banks expect mispriced LOLR support, they may hold inefficiently little liquidity, which provides a rationale for combining ex ante liquidity regulation with an ex post LOLR.

Robatto (2024) also investigates the interaction of the LCR with the LOLR. The author develops a three-period model with near-money assets to evaluate liquidity requirements and central bank liquidity injections during crises. Banks hold reserves or government debt and invest in risky projects. They issue safe and risky claims to households, who must hold liquid assets to transact, and liquid assets feature a liquidity premium. Idiosyncratic shocks render a subset of banks insolvent. The stock of liquid assets contracts, aggregate demand falls, and liquidity premia rise.

Policies affect the economy through their impact on liquidity premia. Liquidity injections through an LOLR expand public liquidity. They lower liquidity premia and raise output, but they dilute the value of households' existing liquid wealth. Households thus prefer moderate ex post interventions. An LCR-like requirement reduces banks' liquidity creation, which raises the liquidity premia. This relaxes liquidity constraints for households but depresses goods demand and output, so producers lose. A key insight is that the two instruments are complementary. Liquidity injections can neutralise the LCR's upward pressure on liquidity premia and thereby enable Pareto improvements by increasing the stock of eligible HQLA available to meet the requirement.[13]

3.2 Empirical work on liquidity regulation

Empirical work shows that banks mostly met the LCR requirement by increasing their HQLA, at times at the expense of their lending, and by somewhat replacing short-term wholesale funding (in particular interbank loans) with more stable retail or longer-maturity liabilities.[14] At the same time, evidence suggests that banks increased their risk-taking in response to liquidity regulation. Table 1 provides a high-level overview of the empirical literature.

Banerjee and Mio (2018) examine the effect of the United Kingdom's individual liquidity guidance (ILG) on UK banks. The ILG is similar in design to the LCR. The authors find that, compared with banks not subject to the ILG, the HQLA share of ILG banks rose substantially (mostly through greater reserve holdings), while short-term intra-financial loans fell almost one for one, leaving lending to the real economy unchanged. Meanwhile, banks' UK retail and corporate deposits rose and their reliance on less stable funding, including short-term wholesale funding and non-UK deposits, declined. The authors find no effect on the pricing of loans or deposits. Exploiting the same regulation, Reinhardt et al (2023) show that banks subject to the ILG reduced their cross-border lending growth, in particular via foreign subsidiaries in countries whose government debt was eligible as HQLA.

[13] The model does not consider how the presence of a LOLR affects moral hazard and banks' incentives to screen and monitor ex ante, which is an important caveat to keep in mind when interpreting the results.

[14] The finding that banks mostly adjust their stock of HQLA in response to the LCR is also confirmed in a survey-based analysis by the BCBS (2019).

Overview of empirical papers on the Liquidity Coverage Ratio Table 1

Source	Setting	Main findings
Banerjee and Mio (2018)	UK; ILG DiD, 2010–12, quarterly	HQLA rose (notably reserves); short-term intra-financial loans fell almost one for one; lending to the real economy was unchanged. UK retail and corporate deposits rose; reliance on less stable wholesale and non-UK deposits declined.
Reinhardt et al (2023)	UK; ILG DiD, 2009–15, quarterly	Cross-border lending growth fell for ILG banks, especially via foreign subsidiaries where government debt qualified as HQLA.
Bonner and Eijffinger (2016)	Netherlands; DQLR RDD, 2004–11, monthly	Long-term lending declined. Long-term borrowing volumes increased; long-term borrowing rates rose. Interest margins declined.
Ananou et al (2021)	Netherlands; LBR DiD, 2000–06, annual	Lending expanded; corporate and retail loans increased more than mortgages. Higher equity and retail deposits facilitated balance sheet expansion.
Bruno et al (2018)	Europe; LCR event study, 2007–13, daily	Modest negative abnormal returns, less negative where HQLA were higher and mismatches smaller.
Sundaresan and Xiao (2024)	US, LCR DiD, 2011–17, quarterly	More-exposed banks increased HQLA and reduced balance sheet lending to firms/households. Only modest increases in stable funding. Liquidity risks migrated to non-LCR banks.
Roberts et al (2023)	US; LCR DiD, 2009–17, quarterly	Share of loans fell via tighter lending standards; liquidity creation declined; fire-sale externality costs were mitigated. Dependence on liquid borrowing decreased; effects stronger with lower ex ante stable funding. Lower on-balance sheet risk via fewer loans.
Raz et al (2022)	US; LCR DiD, 2010–17, quarterly	HQLA share increased, largely by cutting short-term interbank lending; shift towards complex illiquid assets increased opacity. Also disclosure quality was weaker.
Bosshardt et al (2024)	US; LCR DiD, 2010–19, quarterly	Banks with more stable funding raised liquid asset ratios by relatively less and originated relatively riskier syndicated loans.
Curfman and Kandrac (2022)	US; Regulation D RKD, 1992–2007, quarterly	Higher marginal HQLA requirements reduced loan-to-asset ratios, slowed loan growth and lowered profitability. Banks subject to tighter requirements before the Great Financial Crisis had significantly lower failure probabilities.

This table provides details on the setting and key findings of empirical work on the LCR. HQLA = high-quality liquid assets; ILG = individual liquidity guidance; DQLR = Dutch quantitative liquidity requirement; LBR = liquidity balance rule; DiD = difference in differences; RDD = regression discontinuity design; RKD = regression kink design.

Studying the Dutch quantitative liquidity requirement, which is structurally comparable to the LCR, Bonner and Eijffinger (2016) find that banks subject to the requirement increased long-term borrowing volumes and curtailed long-term lending. Consistently, long-term borrowing rates increased for banks subject to the requirement. As corporate lending rates did not adjust, overall interest margins declined. Also focusing on the Netherlands, Ananou et al (2021) study the liquidity balance rule (LBR), which requires banks to hold HQLA to cover 30-day net stressed outflows. They find that, compared with a control group of other European banks, increased equity and an inflow of retail deposits allowed Dutch banks to increase lending despite having to meet the LBR requirements. Dutch banks' stock of corporate and retail loans increased more than that of mortgage loans.

For a larger sample of European banks, Bruno et al (2018) find that policy announcements regarding the LCR led to modest negative abnormal returns. They find price responses are lower for banks with more ex ante HQLA and smaller long-term funding mismatches. The authors interpret their findings to mean that equity markets perceive liquidity regulation as a cost that lowers bank profitability.

For the United States, evidence suggests that banks subject to the LCR increased their share of HQLA but reduced their loan supply to firms and households.[15] Comparing banks that are subject to the LCR with those that are not based on a size threshold, Roberts et al (2023) find that LCR banks decreased their share of illiquid assets (mostly loans, through tightening lending standards) as well as their dependence on liquid borrowings. This resulted in less bank liquidity creation overall. Effects are generally stronger for banks with less stable funding ex ante. However, the LCR appears to mitigate the cost of fire-sale externalities. In a similar setting, Raz et al (2022) find banks subject to the LCR increased their HQLA share, largely by reducing short-term interbank lending.

Sundaresan and Xiao (2024) focus on banks subject to the LCR in the United States. The authors compare banks with greater exposure to liquidity regulation, measured by a larger gap between their pre-regulation liquidity ratios and the mandated level, with those with smaller exposure. They find that more-exposed banks strongly increased their HQLA share but increased their share of stable funding only modestly, thereby mitigating their liquidity risk. The increase in HQLA, however, came at the expense of balance-sheet-based lending to firms and households. Moreover, liquidity risks appear to have migrated to banks not subject to the LCR, offsetting some of the aggregate gains.

Finally, the LCR appears to have encouraged greater bank risk-taking and investments in opaque assets by requiring banks to hold more liquid assets that yield relatively lower returns. In the US context, Raz et al (2022) show that as mandated liquidity rose, banks invested more in harder to value and complex illiquid assets: their disclosure quality declined, and asset opacity rose. Overall, the increase in opacity resulting from holding more opaque assets dominates the reduction in opacity from holding additional HQLA. Bosshardt et al (2024) show that the LCR can increase incentives to take risks for banks with stable funding. To establish this finding, the authors use the share of banks' total liabilities held by insurers in the form of bank bonds as a measure of funding stability. Banks with a higher share increased their

[15] Ihrig et al (2019) provide details on how US banks subject to the LCR adjusted their mix of HQLA assets.

liquid asset ratio by relatively less in response to the introduction of the LCR and also originated relatively riskier syndicated loans.[16]

Beyond work on the effects of the LCR, a related literature uses the banking turmoil of 2023 to draw lessons for funding fragility. Most papers focus on the United States. Jiang et al (2024) show that banks with larger shares of uninsured deposits were more vulnerable once rate hikes generated mark-to-market losses. Drechsler et al (2023) argue that the rapid monetary tightening eroded the franchise value of uninsured deposits, thereby increasing liquidity risk and run propensity. Benmelech et al (2023) and Cookson et al (2025) find that withdrawals by large depositors and greater social media attention are associated with steeper bank stock price declines during the banking turmoil. Using high-frequency interbank payments data, Cipriani et al (2024) show that runs were driven by large depositors and were related to weak balance sheet characteristics, in particular among publicly traded banks, suggesting a role for depositor coordination. For major European banks, however, Fascione et al (2025) find that online banking and social media have had no discernible impact on deposit volatility. In Switzerland, Credit Suisse faced rapid withdrawals led by international wealth management clients, underscoring the fragility of large non-operational, uninsured deposits (Lengwiler and Weder di Mauro (2023); Expert Group on Banking Stability (2023)). In sum, uninsured deposits concentrated among a few large depositors appear to be a common source of vulnerability across the United States and Switzerland (Acharya et al (2023)).

4. Discussion and outlook

The theoretical and empirical literature has made some progress relative to the work summarised in De Nicolo (2016), Diamond and Kashyap (2016) and Allen and Gale (2017). Yet open questions remain. In the following we discuss some of these, starting on the empirical front.

First, there is little work on the appropriateness of the calibration of run-off rates. As discussed in section 2, run-off rates are derived from a hypothetical scenario based on the experiences before and during the GFC. Since then, structural changes in the economy and the financial sector – ranging from digitalisation to rising corporate and operational deposits – may have changed the fragility of different types of funding. The regional banking turmoil of 2023 highlighted that some deposit types that were previously assumed to be stable can be quite fickle. While recent work by the BCBS takes a first step in assessing the role of various factors, including depositor concentration and digitalisation, during the turmoil (BCBS (2023, 2024)), further analysis is needed.[17]

That said, from a conceptual point of view, assessing the calibration of run-off rates is not straightforward. If run-off rates were stochastically driven by exogenous

[16] In the model, the bank earns a higher expected private payoff from risky, illiquid loans because of limited liability, but risky loans suffer from a fire-sale discount during a run. For banks with stable funding, runs are unlikely, so the cost of holding risky loans is lower, while leaving their upside unchanged, so the bank's optimal portfolio tilts towards higher risk when the LCR tightens.

[17] The analysis by Hong et al (2014) made a first attempt at studying the relative sensitivity of different liabilities. Doerr (2024) provides causal evidence on the role of deposit diversification for funding stability. While work on the 2023 banking turmoil has examined to what extent digitalisation or the presence of large or corporate depositors has made deposits flightier, it has not directly drawn implications for the LCR's design or impact.

factors, the solution would be to construct the empirical distribution and then decide the cut-off point of the distribution that should be covered by HQLA. This would in principle be akin to the approach risk managers take for credit and market risk. However, liquidity risk is endogenous. For instance, in run models that are solved by global games, such as the ones discussed in section 3.1, the region of interest is where banks are solvent but illiquid. If the public signal is sufficiently bad so that everyone knows that the bank is insolvent, then everyone should run and the bank fails. But if one takes this perspective, the rapid run on Silicon Valley Bank is exactly what the model would predict, as it was an insolvent bank. And it may only have been quicker than past runs, as the information needed to assess insolvency was readily available and the few large depositors could coordinate more easily.

Second, no study rigorously examines the effects of liquidity regulation on the real economy or the NBFI sector. Several papers suggest that the LCR has led to a contraction in bank credit supply, but activity may have migrated to other (less regulated) banks or non-bank lenders. Whether the LCR has led to a contraction in aggregate lending, and hence economic activity, remains unclear. To the extent that activity has migrated to the NBFI sector, a closely related question is understanding which types of NBFIs now provide credit and what liquidity risks they pose. If NBFIs performing intermediation activity are subject to similar liquidity risks as banks, this might necessitate a holistic approach to liquidity regulation.[18]

Third, further work is needed to assess the extent to which the LCR dampens or amplifies procyclicality. If institutions are unwilling to use HQLA buffers and reduce their LCR below the regulatory requirement during crises, this may make the LCR a de facto procyclical policy tool.[19] Indeed, banks may paradoxically be forced to sell more of their illiquid assets at fire-sale prices to satisfy regulatory requirements (Coen et al (2019)). Moreover, the LCR may also create incentives for institutions to hoard liquidity to increase or rebuild HQLA buffers.[20] Despite its importance, there is limited empirical work on this question. Looking at the events of March 2020, the BCBS (2022) concludes that banks in some jurisdictions seemed to have acted defensively to keep LCRs above 100%, but not in a way that amplified stress. That said, the same report also concludes that banks' internal risk limits and supervisory liquidity stress tests indicate a lack of willingness by banks to use liquidity buffers in a systemic event, which may amplify stress.[21] In this regard, an interesting policy experiment was conducted in Korea. During the Covid-19 crisis, authorities lowered the LCR requirement and banks used their buffers (Feldberg et al (2020)).

Fourth, the overall effects of the LCR on financial stability are underexplored. As the LCR was explicitly designed to bolster banks' resilience during crises, examining its effects on financial stability seems paramount. But little is known about whether

[18] For example, private credit has grown rapidly over the past two decades and expanded into more and more industries. With their closed-end structure and matched maturity of assets and liabilities, private credit funds may be better positioned to hold long-term loans and attendant risks. But recent developments, including rising leverage and wider participation from retail investors, could introduce liquidity mismatches (Avalos et al (2025); Aldasoro et al (2025)).

[19] Reasons for such behaviour include market stigma, uncertainty about supervisory response or a desire to maintain a certain level of reserves to withstand further stress (BCBS (2021)).

[20] Liquidity hoarding can arise for various reasons. For example, healthy banks may hoard liquidity to buy assets from distressed banks at a discount during crises (Acharya et al (2011)). Other arguments are that it is done for precautionary reasons (Acharya and Skeie (2011)) or signalling purposes.

[21] For example, Ding (2024) shows that a binding LCR can lead to less system-wide liquidity in stress, as those banks with a liquidity surplus are less willing to roll over existing funding and therefore amplify stress for banks that lack liquidity.

the introduction of the LCR has helped in making individual banks more resilient, whether it has prevented spillovers and contagion through fire sales, or whether it has helped reduce bank failures during shock episodes. There are a few exceptions. Hong et al (2014) use data for the pre-LCR period in the United States and conclude that "the overall effects of idiosyncratic liquidity risk measures on bank failures are minimal" and that the LCR has limited effects on bank failures. Curfman and Kandrac (2022), who also focus on the pre-LCR period, find that "banks subject to a higher [HQLA] requirement just before the financial crisis had lower odds of failure". Ananou et al (2025) find the introduction of the Dutch LBR increased bank-level stability and reduced systemic risk.[22]

The lack of theoretical and empirical work implies that it is difficult to assess whether the net effects of the LCR are positive or negative. It therefore remains unclear whether tightening or loosening the requirement would be welfare enhancing. This contrasts with capital regulation, for which the general consensus is that it has net benefits, even if questions about the optimal level remain.[23]

An assessment of the net benefits of the LCR is also hampered by the lack of clarity on its objective. The LCR is designed and described as a microprudential measure. In general discussion and theoretical papers, however, it is usually treated as a macroprudential tool to address externalities arising from fire sales, contagion or inefficient liquidations of long-term projects. An important question is therefore how liquidity regulation could be designed from a macroprudential, system-wide perspective. In this regard, two issues warrant more consideration.

First, what is the optimal amount of liquidity at the level of an individual institution versus at the aggregate level? While holding more liquid assets may make individual institutions appear more sound, it might have unintended consequences for aggregate liquidity insurance if it results in procyclicality because of a lack of buffer usability, as discussed above, or if it undermines private liquidity insurance and secondary market activity (Malherbe (2014); Erol and Ordonez (2017)).

Second, what is the optimal design of liquidity regulation when taking into account the interactions with central bank policies? The LCR's current design does not incorporate central bank lending facilities, even though central banks are the ultimate liquidity backstop during crises. Nor does the definition of HQLA consider central bank eligibility.[24] Consequently, an analysis of pre-positioning collateral with the central bank, as suggested by King (2016) and Hanson et al (2024), remains largely

[22] Related to these issues is the relevance of liquidity-driven bank runs in the first place. Historical evidence for the United States suggests that most failed banks were fundamentally insolvent (Correia et al (2025)). Global long-run evidence suggests that around 15% of systemic bank runs in history are unrelated to fundamentals (Jamilov et al (2024)), but it is unclear how far higher liquidity buffers have helped to mitigate such events.

[23] De Nicolo et al (2014) study the joint impact of capital and liquidity regulation on bank lending and welfare in a calibrated dynamic banking model. They find that moderately stringent capital requirements can raise lending and welfare, while complementary liquidity requirements depress lending and welfare.

[24] This ensures that the LCR rules are globally consistent because eligibility criteria for central bank lending or repo operations vary significantly across countries and facilities (Markets Committee (2022)). Some central banks accept only Level 1 assets as collateral for standard lending operations. Others generally allow for a very broad collateral pool that even includes non-marketable assets such as mortgage pools, which allows banks to transform illiquid collateral into HQLA. Facilities that are designed as liquidity backstops for banks also typically have a broader collateral list than the assets defined as HQLA.

outstanding.[25] Some of the theoretical papers surveyed in this article study optimal liquidity regulation, in particular how an LCR-like requirement compares with a Pigouvian tax or a committed credit facility. But conclusions crucially depend on the assumed frictions in the banking sector and the information environment, and empirical evidence is lacking.[26]

In sum, while the literature on the LCR has provided some answers, many open questions remain. This leaves ample room for more research on the topic.

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[25] When pre-positioning collateral, banks provide the central bank with the necessary documentation and details ex ante, so that collateral is approved, valued and operationally ready to be borrowed against from the central bank when needed (Coelho et al (2024)). Gorton et al (2025) take a first step in studying pre-positioning with supervisory data on collateral pre-positioning by large US banks with the Federal Reserve. They show that banks pre-position almost one third of their unencumbered assets, driven by the desire to protect themselves against risks from run-prone uninsured deposits. More analyses, both empirically and theoretically, on this important topic is needed.

[26] An interesting case study is the Reserve Bank of Australia's Committed Liquidity Facility. As the supply of Commonwealth and state government securities was too small, the Reserve Bank of Australia worked with the BCBS to obtain recognition of a Committed Liquidity Facility as part of banks' HQLA requirements. Under the facility, banks could access a contractual line from the central bank, secured by eligible collateral, for an annual fee. However, it remained largely unused, potentially because of a relatively high fee.

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