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The Basel III framework for liquidity standards and monetary policy implementation

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The Basel III framework for liquidity standards and monetary policy implementation[1]

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Abstract

Basel III introduces for the first time an international framework for liquidity risk regulation, reflecting the experience of excessive liquidity risk taking of banks in the run up to the financial crisis that erupted in August 2007, and associated negative externalities. As central banks play a crucial role in the liquidity provision to banks during normal times and in a financial crisis, the treatment of central bank operations in the regulation is obviously important. To ensure internalisation of liquidity risks (i.e. pricing of liquidity risk) and to address excessive reliance *ex ante* on central bank liquidity support by the banks, the regulation deliberately does not establish a direct close link with the monetary policy operational framework. While this reflects the purpose of the regulation and is also natural outcome of an international rule being applied under a multitude of very different monetary policy operational frameworks, this paper shows that the interaction between the two areas can be substantial, depending on the operational and collateral framework of the central bank. This implies the need for further study and the development of policies at the central bank and regulatory/supervisory side on how to handle these potential interactions in practice.

Key words: Basle III, Liquidity Risk, Banking Regulation, monetary policy implementation

JEL Codes: E58; G21; G28

1. Introduction

Basel III introduces for the first time an international framework for liquidity risk regulation, reflecting the experience of excessive liquidity risk taking and serious flaws in liquidity risk management of banks in the run up to the financial crisis that erupted in August 2007, and associated negative externalities. As central banks play a crucial role in the liquidity provision to banks during

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normal times and in a financial crisis, the treatment of central bank operations in the regulation is obviously important. The regulation does not in its entirety recognise the various central bank frameworks and operations; first, given that it is an international rule applied under a variety of very different monetary policy operational frameworks and, second, to achieve its purpose of liquidity risk pricing and address undue reliance of banks on central banks. However, this paper shows that this separated treatment of the liquidity risk regulation and central bank operations framework can lead to some specific interactions that are not necessarily positive from a monetary policy and financial stability perspective. Berg (2010) puts the issue in a provocative way: "The new international liquidity standards have thus far been set with a blatant disregard for the interaction with central bank collateral rules. The inherent conflict between the two is likely to surface". We argue that while the idea behind the new liquidity regulation to require banks to raise funding at their own capacities on financial markets and thereby internalise liquidity risk is a legitimate one, the interaction with central bank liquidity provision is indeed substantial and will require further study and policy development across the regulatory, supervisory and central bank communities.

With a view to address these negative interactions through specific policies, this note proceeds as follows. First, section 2 recalls the motivation behind the new liquidity risk regulation. Section 3 explains the role of the central bank operational framework, and in particular the collateral framework, for the funding liquidity of banks. In addition the section takes a normative perspective and discusses the reasoning behind the central bank's supportive role of bank funding in a financial crisis. Section 4 simulates in a simple way the interaction between the new regulatory framework and monetary policy operations of central banks, to provide examples of tensions between the two. Section 5 studies how central bank policies influence the ability of banks to fulfil the new liquidity regulation. Section 6 briefly describes some preliminary approaches to address the identified negative interactions. Section 7 concludes.

2. The new liquidity regulation

2.1 The crisis experiences

The financial crisis that started in the summer of 2007 and ravaged through most developed financial markets resulted from extra-ordinary growth in credit and leverage (Financial Stability Forum, 2008). The period before the crisis was characterised by highly benign and reinforcing economic and financial conditions, as reflected by low interest rates and spreads, low volatility and low levels of risk aversion. These conditions increased the level of risk and leverage which borrowers, investors and other financial actors were willing to take. Financial innovation had a significant impact on this process: e.g. credit risk became tradable and easier to hedge, increasing the liquidity of credit assets (at that time). The reinforcing cycle was also fed by the provision of off-balance sheet funding and the

establishment of investment vehicles by banks and other financial players. These developments made banks to increase their reliance on the sale of marketable securities to raise funding and, in addition, provided the market conditions for banks to become more reliant on interbank borrowing (of which a large part was concentrated at the shorter term).

From the end of 2006 and early 2007 the worsening underwriting standards began to clearly affect the delinquencies of US subprime mortgages, investor's growing awareness of the increasing delinquencies started to hit indices based on subprime-related assets. These price falls produced losses and margin calls for investors in securitised products collateralised by subprime mortgages. Additionally, heavy mass downgrades by Credit Rating Agencies of structured products backed by subprime mortgages led to severe loss of investor confidence in a broader set of structured credit. This translated in money market investors unwilling to roll-over investments in asset-backed commercial paper (ABCP) backed by structured credit of conduits and structured investment vehicles (SIVs) in August 2007. The sponsoring banks of the conduits and SIVs started to hoard their liquidity resources and became unwilling to provide liquidity to other market players as they had to fulfil their liquidity commitments to ABCP conduits and SIVs. This led to a severe contraction of activity in the term interbank market. These events implied the definite end and reversal of the positive reinforcing cycle that characterised the financial and economic conditions. By October 2008, interbank lending in the US and in Europe had come to a virtual stand-still.

The sharp reduction in liquidity for structured credit had severe repercussions. It resulted in problematic valuation conditions of structured credit, hedging difficulties, the requirement to finance the structured credit by more long term funding and increased loss of confidence in assessing total credit exposures as concerns grew regarding the quality of the wider set of credit assets. In some cases these conditions required firms to outright sell securities or take off-setting positions, thereby also affecting different asset classes. Overall market events posed severe stress to capital and liquidity bases, raising general counterparty risk concerns between financial players. The heightened counterparty concerns required unprecedented crisis intervention by central banks to stabilize the interbank, foreign currency swap, and secured money market fall-out and restore their functioning (IMF 2008 and 2010).

2.2 Main lessons to learn - a liquidity risk perspective

A key aspect of the crisis has been the over reliance of commercial and investment banks (as well as entities of the shadow banking system) on short-term market funding to finance asset of longer-term holding periods. The roll-over of the short-term market funding to finance illiquid assets showed too fragile and to heavily rely on market confidence. As firms could no longer fund their activities they

resorted to fire sales of portfolios, which led to losses at the capital side and further loss of confidence (Financial Stability Forum, 2008).

This over reliance on short term market funding resulted from faulty assumptions regarding asset liquidity or from the plain disregard of market liquidity risk as well as from moral hazard with respect to the role of central banks as lenders and liquidity providers of last resort. The growth of securitization and credit risk transfer made firms more dependent on market conditions to access funding. However, market illiquidity can pose severe funding difficulties to firms as they are unable or have it more difficult to roll-over maturing funding or liquefying assets through repos and outright sales or face cash drains through increasing margin requirements. In addition, market developments made that the composition of this funding had also changed, intermediaries such as money market mutual funds became important suppliers of funding in contrast to more stable depositors (IMF 2008 and 2010). The risks resulting from the assumption of effective, efficient and continuous markets, the wider use of short-term wholesale funding markets and greater maturity mismatch between assets and liabilities were not fully appreciated by most financial players.

In addition, the provision of liquidity and credit lines to off-balance sheet vehicles, that invest in long-term assets and borrow with short-term funding, actually brought the maturity mismatch risk back to the banks (Brunnermeier 2009). The changing activities showed to pose many other forms of contingent liquidity risk to financial institutions. The contingent liquidity risk is introduced through a variety of options that are explicitly or implicitly embedded in financial contracts (from retail loans to derivative transactions). The crisis experiences showed a clear failure at many financial firms to appropriately assess the risks and price the contingent liquidity risk from these options. This incorrect risk assessment and pricing made that some financial firms faced extreme unexpected collateral calls requiring unanticipated needs for contingent funding during the crisis. Many financial firms also misjudged the importance of reputational risks that arise from explicit and implicit commitments of off-balance sheet vehicles.

Also the reliance on foreign currency markets was affected by disruptions in the swap market (from increased counterparty concerns) making some cross-border banks having difficulties to match their specific currency liquidity requirements with the currency in which they had their available cash.

2.3 The regulatory liquidity risk framework

The crisis experiences showed that many fragilities at financial institutions accounted for the deep financial crisis (deficiencies of corporate governance, risk management and internal control). One of the critical issues that have been identified has been the inadequacy of the liquidity risk management in many financial firms (Senior Supervisors Group, 2008 and 2009). In reaction, to raise the standards

of the liquidity risk management and supervisory practices the Basel Committee has updated and issued their "Principles for Sound Liquidity risk Management and Supervision" in 2008 (BCBS, 2008). In addition, to strengthen the resilience of international banks to liquidity shocks and to further harmonise the liquidity risk supervision, the G20 requested the Basel Committee to define a liquidity risk framework that would promote stronger liquidity buffers at financial institutions. The liquidity risk framework has been issued, as part of the Basel III regulatory reform package on 16 December 2010 (BCBS 2010).

The liquidity risk framework consists of two main measures that have as purpose to raise the resilience of financial firms to liquidity shocks and address the fragilities identified by the crisis. The measures are complemented with a minimum set of monitoring tools to address certain specific or other dimensions of liquidity risk .

The Liquidity Coverage Ratio (LCR) has as purpose to establish a minimum level of high quality liquid assets to withstand an acute stress scenario lasting one month. The stress scenario is a regulatory defined stress composed of "a conservative bank level and plausible severe system wide shock". Provided the balance sheet and the firm's activities this stress defines the potential net cash drain. To determine the cash flow drain every source of liquidity risk has to be regarded which could affect the liquidity position of the financial firm. For instance, margin requirements from derivative transactions and liquidity support to conduits through committed facilities are captured within the measure. The liquidity buffer thus has to enable the firm to survive through a cash flow drain that results from a stress lasting one month. By requesting the liquidity buffer to consist of high quality liquid assets, which provide relatively low yields, the measure internalises the liquidity risks from the activities of the banks, as holding the high quality liquid assets is costly to the bank.

The second measure, the Net Stable Funding Ratio (NSFR), is a more structural measure and has as purpose to ensure that the longer-term assets or activities are funded by more stable medium or longer-term liability and equity financing. The ratio is a more structural funding measure as it relates the maturity structure of the asset side with the liability side of the balance sheet. In broad, it requires that longer term assets are financed by funding of one year and more. The measure thus links the available stability of the funding with the required stability of the asset, or in other words, the illiquidity of the assets or activities of the firm.

Both measures clearly address the fragilities identified by the crisis and strive to increase the resilience of banks to liquidity shocks by establishing minimum levels of buffers and by structurally matching more closely the term structure of both sides of the balance sheet. This increased resilience will make that firms e.g. do not have to resort to fire sales as last measure when they can no longer fund their

portfolios. The subsection below will discuss particular aspects of the LCR measure as in the following sections the focus will be on the interactions between the LCR measure and monetary policy. For a more detailed discussion of both regulatory measures we refer to the regulatory Basel III text "International framework for liquidity risk measurement, standards and monitoring" (BCBS 2010).

2.4 The liquidity risk coverage ratio in more detail

The LCR measure makes a comparison between the liquidity buffer and the net cash outflow over a 30-day period. Or more specifically the ratio is defined as:

$$LCR = \frac{liquid\_non-encumbered\_assets}{30\_days\_net\ cash\_outflow} \geq 1$$

The LCR standard would require that the ratio is no lower than 100%.

We start this section with a discussion of the definition of liquid assets under the new regulation. Second, we shortly discuss how cash outflows and inflows over the 30-day period are determined in the regulation and particularly focus on the elements that interact with the monetary policy operations.

2.4.1. Definition of liquidity buffer

The new regulation defines two categories of liquid assets. Level 1 liquid assets are mainly composed of cash and central bank reserves[2] and government and public sector entity debt qualifying for the 0% risk weight under the Basel II standardised approach. The qualifying assets are subject to general additional criteria of being traded in large, deep and active repo or cash markets, proven record of a reliable source of liquidity even during stressed conditions and the assets cannot be an obligation of a financial institution[3]. For sovereigns that do not have a 0% risk weight, the inclusion of domestic sovereign debt is allowed in the local currency as well as the foreign currency[4]. The level 1 assets are further also required to "ideally be central bank eligible for intraday liquidity needs and overnight liquidity facilities in a jurisdiction and currency where the bank has access to the central bank". The level 2 liquid assets mainly consist of government and public sector entity debt qualifying for the 20%

[2] To the extent that the reserves can be drawn in times of stressed conditions.

[3] These criteria are of utmost importance as it is not an asset on itself that will determine whether it is "liquid", however, it is the market in which it is traded that will determine its liquidity value. Hence, to increase the liquidity resilience of banks, regulators should also improve the transparency, robustness and resilience of the markets. In addition, when assessing the liquidity position also the state and development of the markets in which the banks liquid assets are traded should be considered.

[4] To the extent that the foreign currency matches the currency needs of the bank's operations in that jurisdiction.

risk weight under Basel II and high quality corporate and covered bonds. The corporate and covered bonds cannot be issued by a financial institution or by the bank itself and must have at least a AA- credit rating assigned. As for the level 1 assets the same criteria hold for the level 2 assets; namely that the securities have to be traded in large, deep, liquid and active repo or cash markets, must have a proven record as a reliable source of liquidity and meet central bank eligibility for intraday liquidity needs and overnight liquidity facilities. The level 2 assets can comprise no more than 40% of the liquidity buffer. This cap also comprises the cash and other level 1 assets that would be financed through secured funding transactions that would mature within the 30-day period. A 15% haircut has to be applied to the market value of the level 2 liquid assets.

This definition of liquid assets, which constitute the liquidity buffer, results from the purpose of limiting the set of assets to those assets that most likely will allow banks to generate liquidity during a period of stress (e.g. through repo markets). This relates to a basic notion of the regulation that the firm has to rely on its own capacities to raise necessary funding. Moreover, requiring high quality liquid assets poses a cost to the firm to hold the buffer so that the liquidity risk is internalised within the bank (or put differently the regulation requires banks to price their liquidity risk). However, the list of liquid assets cannot be defined too narrowly as this could entail concentration risks, resulting in extreme volatility of the value of the liquidity buffer or liquidity raising capacity and systemic risks. To allow fulfilling these objectives and to ensure that the regulation establishes a 'stability buffer' before reliance on central bank support, the definition of liquid assets purposefully does not equal the respective central bank's eligible collateral framework of the respective jurisdiction. This approach has been acknowledged by the IMF (2010) "to encourage appropriate pricing of liquidity risk in good times to limit its negative impact in times of market stress" and is also in line with a CGFS 2008 report that proposes to address concerns of over-reliance of banks on central bank "a possible offset would be to implement tighter supervisory and prudential policies concerning the management of liquidity…".

2.4.2 Net cash outflows

This section briefly discusses the treatment of cash in and outflows in the regulation and particularly focuses on the treatment of the in and outflows of monetary policy operations.

To determine the cash outflows (inflows) of the liabilities (assets), stress (run-off) factors are applied according to the characteristics of the assets, liabilities and the counterparties. Funding is categorised along retail deposits, unsecured wholesale funding, secured funding and categories that comprise of, for instance, contingent funding liabilities. These categories and subcategories of funding receive run-off factors according to the "stickiness" of the liabilities. With respect to funding obtained through operations with the central bank the regulation foresees the following treatment. Unsecured central bank funding receives a run-off rate of 75%, in other words the funding that is to mature within the 30

day period is to leave the bank for 75% of the amount. Secured central bank funding receives run-off rates according to the quality of the underlying collateral. Secured funding backed by Level 1 assets is assumed to be extended (and no run-off rate applies), funding backed by Level 2 assets receives a cash outflow or run-off of 15% and central bank secured funding collateralised by other assets than Level 1 and Level 2 assets are assumed to run-off at a rate of 25%.

The regulation applies a limitation to the recognition of inflows at the general level to prevent banks to unduly rely on unrealistic assumptions of cash inflows to meet the liquidity requirements. The total amount of inflows that can cover outflows is limited to 75% of total outflows, this establishes a minimum level of liquidity buffer (of 25% of outflows). In addition, relative limits to counterparties have been introduced as well. Inflows from retail customers can maximally be 50% of contractual inflows, inflows from non-financial wholesale counterparties are also limited to 50% of contractual inflows and inflows from financial institutions are limited to 100%.

2.5 Next steps in the implementation of the regulation

The introduction of both liquidity risk standards as minimum requirements is subject to careful assessment of the impact of the regulation on banks, financial markets and the wider economy. The assessment of the measures will be performed during the so-called observation periods. The observation period for the LCR would span until end of 2014, for the LCR to be introduced as a minimum requirement by January 1st 2015. The NSFR would follow and would be introduced by January 1st 2018.

3. Central bank as liquidity providers to banks

This section explains that central banks are crucial liquidity providers to banks in normal times and even more in times of financial crisis. This holds at the aggregate level but also at an individual bank level. This crucial function of liquidity provider in normal times is explained through the concept of the liquidity deficit of the banking system vis-à-vis the central bank (subsection 3.1). The availability of central bank eligible collateral determines the related central bank borrowing potential, so the role of collateral eligibility is introduced (subsection 3.2). The section then turns from the aggregate banking system perspective to the perspective of individual banks and their funding liquidity risk (subsection 3.3). The section also reviews, as an example, central bank collateral availability in the case of the euro area (subsection 3.4). Finally, the last subsection introduces the crucial role of central banks as liquidity providers during stressed conditions.

3.1 The liquidity deficit of the banks is determined by the central bank balance sheet

As the previous section discusses, the new regulation assumes that the firm in first instance should rely on its own capacities to raise funding and not to rely on central bank funding. However, to qualify this assumption, it is important to recall the logic of the banks' funding dependence on the central bank, both at an aggregate and at an individual level. The liquidity deficit of the banking system vis-à-vis the central bank is what the banks need to finance from the central bank on a regular basis through collateralized credit operations. As will be illustrated further in particular in section 5, the liquidity deficit of the banking system is not irrelevant in determining the liquidity of banks as measured through the LCR, while at the same time the liquidity deficit is not directly related to any liquidity risk measure of individual banks. It is crucial to note that the liquidity deficit of banks vis-à-vis the central bank is determined by decisions of economic agents *other than the banks*. This contrasts with the potential assumption that the liquidity deficit is determined by the banking system, and that incentives applied to banks would suffice to reduce it to make banks independent of the central bank.

The starting point of the banking system's liquidity deficit is, maybe surprisingly, the household, who holds first only real assets, but then diversifies into financial assets. We build the understanding of the liquidity deficit of banks in three steps. The liquidity deficit of the banking system vis-à-vis the central bank is presented within a closed system of financial accounts including the households, the banking system, the corporate sector, and the central bank.

Step 1: households diversify from real assets into banknotes, whereby the freed real assets are held by corporates. Our system of financial accounts consists of two "real" sectors, namely households and corporates, and two financial sectors, the banks and the central bank. The latter two do not hold real assets, but only financial assets. Moreover, the central bank wants to transact only with the banking system. At the beginning, only the household holds real assets equal to its equity (E). The corporate sector will hold real assets equal to what the household does not want to hold from its initial endowment, which is what the household has diversified into financial assets. Corporates are, in the simplest case, financed only via banks. In step 1, the bank finances only through the central bank, namely an amount equal to banknotes in circulation (B). One may imagine that the bank first borrows the banknotes from the central bank, then exchanges them with the household against real assets, and then sells the real assets to the corporates, who refinance them through loans from the bank.

After this first step, the system of financial accounts looks as follows.

Household			
Banknotes	B	Equity	E
Real assets	E-B		

Corporate			
Real assets	B	Liabilities to the banks	B

Bank			
Claims to corporate	B	CB borrowing	B

Central bank			
Borrowing to banks	B	Banknotes	B

Step 2: households diversify into deposits. When households want to diversify their assets further, namely into deposits with banks (D), then this necessarily frees additional real assets for the corporate sector. The volume of household deposits increases correspondingly the length of the bank's and the corporate's balance sheet.

Step 3: outright holdings of corporate bonds by the central bank. One can now introduce central bank outright holdings, and it is assumed in this example that these outright holdings are claims against corporates in the form of corporate bonds (CC^{CB}). This direct refinancing of the corporates by the central bank (i) reduces the need of the corporate to refinance through the bank and (ii) thereby reduces the need of the bank to refinance through the central bank.

After steps 2 and 3, the closed system of financial accounts of the four economic sectors takes the following form.

Household			
Banknotes	B	Equity	E
Deposits bank	D^{Bank}		
Real assets	E-D^{Bank}-B		

Corporate			
Real assets	D^{Bank} + B	Liabilities to the banks	D^{Bank} + B-CC^{CB}
		Liabilities to central bank	CC^{CB}

Bank			
Claims to corporate	D^{Bank} + B-CC^{CB}	Deposits of HH	D^{Bank}
		CB borrowing	B-CC^{CB}

Central bank			
Claims to corporates	CC^{CB}	Banknotes	B
Borrowing to banks	B-CC^{CB}		

What needs to be retained in the present context is that banknotes in circulation (determined by the household) and the decisions of the central bank to hold assets outright mechanically determine the dependence on the banking system of the central bank. By introducing additional sectors (e.g. the Government and the rest of the world), and by introducing links between these sectors and the ones depicted above, additional influences on the liquidity deficit arise, but the conclusion that those are exogenous to the banking system remains.

It should be noted that the logic above does not exclude that a banking system could be in a liquidity surplus vis-à-vis the central bank, namely if the central bank buys more corporate bonds than the amount of banknotes demanded by the household. When the central bank buys corporate bonds from the corporates (say with banknotes), the corporates will use the proceeds to pay back their loans from banks, and the banks will hold banknotes that they will return to the central bank, which credits their sight accounts correspondingly. The implied excess deposits of banks with the central bank would drive short term interbank interest rates to zero, unless the central bank would absorb them through some liquidity absorbing operations, or by imposing reserve requirements. In many countries, the banking system is actually in a liquidity surplus vis-à-vis the central bank as the central bank holds large amounts of claims against the rest of the world – namely foreign reserves.

If one accepts the fact of an exogenous liquidity deficit of the banking system, and the huge cross-country diversity of this measure due to e.g. diversity of banknote demand by households and of central bank policies with regard to outright holdings of assets, one is tempted to conclude that a liquidity regulation (which is partly motivated by reducing dependence of banks from the central bank) without any reference to this concept may be in danger to overlook an important dimension.

Also the need for central bank eligible collateral will depend on the size of the liquidity deficit. For instance, if a banking system operates in a liquidity surplus, then there are little reasons for the central bank to make eligible a large set of collateral. If in contrast the liquidity deficit to be covered through reverse operations is huge, then the central bank must ensure substantial collateral availability. Also, when business models of banks are diverse, and if inter-bank liquidity shocks tend to be substantial, there are more reasons to allow for a large set of eligible collateral.

The diversity of liquidity deficits and of collateral frameworks implies that applying a uniform liquidity regulation to all banks internationally, in the absence of 'compensatory' adjustments of the operational and collateral frameworks of central banks, would lead to different incentives for banks across jurisdictions.. Conceptually, there are four alternatives to deal with these costs of regulation: First, to accept differences across jurisdictions.. Second, to adjust the collateral and operational frameworks of central banks with the aim to minimize distortions. Third, to allow for flexibility of liquidity rules across jurisdiction and fourth a combination of the above. The following sections illustrate that ignoring central bank collateral eligibility is not a way to ensure a level playing field.

3.2. Central bank collateral eligibility and haircuts

A second key aspect of central bank operations that affects the funding of banks is the collateral framework of the central bank. Let $A = \{a_1, a_2, ...a_n\}$ be the vector of assets of a certain bank, so for

instance a_1 is deposits with the central bank, while a_n could be idiosyncratic impaired loans, whereby also different maturities could constitute different elements of the array.

On each of these assets, **the central bank decides on collateral eligibility**, and for the eligible ones, it decides on a haircut. Let the array of central bank haircuts be $CH = \{ch_1, ch_2, ..., ch_n\}$, with $1 \geq ch_n \geq ch_{n-2} ... \geq ch_1 \geq 0$. Haircuts of 1 are equivalent to a non-eligibility of the respective assets. The total central bank borrowing potential of the representative bank is therefore $BP_{CB} = \sum_i a_i (1 - ch_i)$. A part of the borrowing potential may be used already through central bank borrowing or through repoing in private markets. Usually, the central bank eligible set of assets will be larger than the one in the interbank market because haircuts are available as an effective risk mitigation tool to the central bank, while it is not an effective tool if both counterparties in the deal are similarly of relevant credit risk (see also section 3.5).

The setting-up of a central bank's collateral set and associated risk control framework has to take into account the uneven suitability of financial assets for use as central bank collateral and their ex ante heterogeneous risk properties. The following specific five-step approach was proposed by Bindseil and Papadia (2000) (see also Chailloux et al 2008):

1. First, a list of all asset types that could be eligible as collateral in central bank credit operations has to be established. The assets in the list will have different risk characteristics (liquidity, transparency, correlation with systemic economic risk factors, existence of a market to establish market valuations, ability of the central bank to calculate theoretical values, etc.), which implies that different risk mitigation measures are needed to deal with them.
2. The specific aim of risk mitigation measures is to bring the residual risks that are associated with the different types of assets to the same level, namely the level that the central bank is ready to accept. Risk mitigation measures are costly and, since they have to be differentiated across asset types[5], their

[5] Since the risk associated with collateralized operations depends, before the application of credit risk mitigation measures, on the type of collateral used, the risk mitigation measures will need to be differentiated according to the collateral type to ensure consistent compliance with the defined risk tolerance of the central bank. The following three risk mitigation measures are typically used in collateralized lending operations. (1) Valuation and margin calls: collateral needs to be valued accurately to ensure that the amount of central bank money provided to the counterparty does not exceed the collateral value. As asset prices fluctuate over time, collateral needs to be revalued regularly, and new collateral needs to be called in whenever a certain trigger level is reached. (2) Haircuts: in case of counterparty default, the collateral submitted by that counterparty needs to be sold. This takes some time and, for less liquid markets, a sale in the shortest possible time would have a negative impact on prices. To reduce the probability of losses at liquidation, a certain percentage of the collateral value needs to be deducted when accepting the collateral, to establish what amount of central bank reserves can be provided in exchange of the collateral. (3)Limits: to avoid concentration, limits may be imposed, which can typically take one of the following two forms: (i) Limits for exposures to individual counterparties (e.g. limits to the volume of refinancing provided to a single counterparty). (ii) Limits to the use of specific collateral by single counterparties: e.g. percentage or absolute limits per issuer or per asset type can be imposed.

costs will also differ. The same applies to handling costs: some types of collateral will be more costly to handle than others. Thus, the fact that risk mitigation measures can reduce residual risks for a given asset to the desired level, is not sufficient to conclude that such an asset should be made eligible. This also requires the risk mitigation measures and the general handling of such a type of collateral to be cost effective, as addressed in the next two steps.

3. The potential collateral types should be ranked in increasing order of cost, whereby the ranking should reflect the collateral value per unit after haircut.

4. The central bank has to choose a cut-off line in the ranked assets on the basis of a comprehensive cost–benefit analysis, matching the marginal social benefits of central bank collateral with its increasing marginal cost. The social benefits of enlarging the collateral set are very high at the beginning, because a too small collateral set interferes with a smooth monetary policy implementation and the implied lack of liquidity buffers in the form of central bank borrowing potential is detrimental to financial stability. The larger the collateral set, the less likely it is that liquidity absorbing shocks to individual banks or to the banking system as a whole exhaust the collateral buffers. Therefore, the marginal value of further increases of collateral buffers become lower and lower, when the eligible collateral set grows. On the other side, as the collateral types are ranked in this exercise from the most convenient and hence cheapest to use, to the least convenient ones (which are expensive to provide, difficult to risk manage and to handle; which need to be made subject to high haircuts, etc), the marginal cost curve of widening the collateral set increases. In view of the decreasing marginal social benefits, and the increasing social cost of widening the central bank collateral set, a unique optimum can be identified.

5. Finally, the central bank has to monitor how the counterparties use the opportunities provided by the framework, in particular which collateral they use and how much concentration risk results from their choices. The actual collateral use by counterparties, while being very difficult to anticipate, determines the residual credit risks borne by the central bank. If actual risks deviate much from expectations due to unexpected collateral use practices, then there may be a need to revise the framework accordingly.

The central bank cannot (and should not) protect itself at 100% from risks, since some extremely unlikely events may always lead to a loss (e.g. the sudden simultaneous defaults of both the counterparty and the issuer of the collateral). Therefore, some optimal risk tolerance of the central bank needs to be defined and adequate mitigation measures must be derived from it.

In sum, the central bank collateral framework and risk control measures should be designed in a rational way in which social costs and benefits of collateral eligibility should be balanced.

3.3 Individual banks' liquidity management and liquidity risk

Now, we bring together the system of financial accounts establishing the liquidity deficit of the banking system vis-à-vis the central bank, with the role of central bank collateral eligibility, and at the same time switch from a pure macro- to a micro-economic perspective.

To describe the funding stress at banks, we need to modify the representation given in the financial accounts above by representing individual banks and their respective sources of liquidity stress. The simplest way for this is as follows. We assume that the central bank holds only claims to banks equal to banknotes (i.e. it does not hold corporate bonds). However, banks now hold separate deposits with two banks, and there are two sorts of liquidity shocks, an aggregate shock η, and a deposit shift shock μ (see also Bindseil 2011). We can assume those shocks to follow a certain probability distribution. For instance, we could assume very simply that both are independently normal distributed with expected value of zero and standard deviation σ_μ, σ_η.

Household			
Banknotes	$B_0 + \eta$	Equity	E
Deposits bank	$D^{Bank1} - \eta/2 + \mu$		
Deposits bank	$D^{Bank2} - \eta/2 - \mu$		
Real assets	$E - D^{Bank1} - D^{Bank2} - B_0$		

Corporate Sector			
Real assets	$D^{Bank1} + D^{Bank2} + B_0$	Loans from banks	$D^{Bank1} + D^{Bank2} + B_0$

Bank 1			
Loans to corporate	$D^{Bank1} + B_0/2$	Deposits of HH	$D^{Bank1} - \eta/2 + \mu$
		CB borrowing	$B_0/2 + \eta/2 - \mu$

Bank 2			
Loans to corporate	$D^{Bank1} + B_0/2$	Deposits of HH	$D^{Bank2} - \eta/2 - \mu$
		CB borrowing	$B_0/2 + \eta/2 - \mu$

Central bank			
Borrowing to banks	$B_0 + \eta$	Banknotes	$B_0 + \eta$

Liquidity buffers of banks may be defined either as a deterministic or as a stochastic concept. A deterministic concept is, for instance, "Distance to Fire Sales" = DFS = the maximum amount of deposit withdrawals that a bank can handle within a certain time horizon before having to fire-sale corporate loans. We will come back to this concept later. A stochastic concept would be "Probability of liquidity" = PL = the *probability* that the bank does not need to fire-sale assets in a certain time horizon. To a certain extent the LCR may be interpreted along such a stochastic concept, as it refers to a stress scenario. This stress scenario is a sort of tail event, which is assumed to have a certain likelihood. The regulation requires that a bank should be able to withstand the specified tail event, i.e. the event of illiquidity has a required probability (1-PL) below the assumed probability of the stress event underlying the LCR. In the simple model above, liquidity buffers must follow from the eligibility of corporate loans for central bank operations. Indeed, the banks must refinance in total the amount B from the central bank, and as central bank funding is always collateralised, it seems that in

this example the central bank must have accepted corporate loans as collateral. Only few central banks do that in fact, and those, like the Eurosystem, who do it, impose relatively high haircuts on corporate loans. Two techniques can be employed by banks to increase the two liquidity measures (DFS and PL) in this simple model:

- *Transform a part of the corporate loans into ABS or corporate bonds (the latter needs to be done at the initiative of the corporates).* This requires some investments in terms of increased transparency, legal documentation, listing fees, etc. There is an increasing marginal cost in doing so, as the corporate claims are suitable for that to a different extent (transforming the small loan to the bakery next door is prohibitive). The advantage of corporate bonds (or ABS) is that, if they are high quality, they can (i) be sold at relatively limited discounts (lower discounts than those of a loan book that is liquidated under stress) in the case of a funding crisis (in particular if the origin of the crisis is not related to the corporate sector); (ii) be submitted with the central bank as collateral, at lower haircuts than corporate loans (who are mostly not eligible at all).
- *Transform a part of the household deposits into long term deposits.* Again, this comes at some cost, as the households have a preference for short term deposits that they can withdraw every day.

By assuming concrete marginal costs for the two types of activities, and for assuming concrete costs of illiquidity, one can calculate the level of liquidity that the banks will choose. By adding also a model of systemic externality, one can determine the degree of under-investment into liquidity, and hence the need to impose a higher degree of liquidity through regulation. In reality, there is of course a large variety of assets and liabilities, which are all distinct in terms of their properties relevant for the overall funding liquidity of the bank. For assets, the main properties are asset liquidity and central bank repo eligibility, while for liabilities, it is maturity and likelihood of roll over at maturity. For all these properties, stress scenarios need to be considered. One may assume that the less liquid the asset, the higher the expected remuneration, everything else equal (since the more liquid assets provide by definition an extra service, which in market equilibrium will lead to a higher price, and hence a lower yield). Therefore, from a return point of view, banks have a preference for holding less liquid assets. Still, they diversify and hold some more liquid assets because they acknowledge liquidity risk. However, at the same time, they ignore the negative systemic externalities of liquidity stress, and hence tend to hold less liquid assets than in the social optimum (see also IMF 2010). The same holds for the maturity and likelihood of roll over at maturity of bank liabilities.

3.4 Collateral availability: the case of the euro area

To assess the role of central bank collateral eligibility for the funding liquidity of banks, we consider the case of the euro area. Four concepts have to be distinguished in terms of central bank collateral availability:

- **Total eligible collateral:** these are all eligible marketable assets that have been issued. The following table provides an overview for Eurosystem eligible securities issued, as at end 2009. It appears that "highly liquid" assets will be around ½ of total central bank eligible assets.

Eligible assets	**End-2009**	
	Value (in bn euro)	% over total
Central Government	5,420	41.0%
Regional Government	341	2.6%
Covered bank bonds	1,378	10.4%
Corporate bonds	1,398	10.6%
Unsecured bank bonds	2,853	21.6%
ABS	1,337	10.1%
Other marketable assets	491	3.7%
Total	**13,219**	**100.0%**

- **Total eligible collateral held by banks** with access to Eurosystem credit operations: large parts of eligible securities may be held by non-banks, and may therefore be unavailable to banks as source of liquidity.
- **Total unencumbered collateral** held by banks with access to Eurosystem credit operations. Eligible central bank assets may be encumbered either by being already used to secure central bank credit, or by being used to collateralise intra-bank liabilities (repos or exposures resulting from OTC derivatives). While the central bank credit of the banks is known - it stood at EUR 754 billion at end December 2009 - the amount of collateral used to secure interbank liabilities is estimated to be in the order of EUR 350 billion (at end 2009 – see ECB monthly bulletin).
- **Total collateral posted by banks with the Eurosystem**: this is what the banks have actually transferred to the collateral account with the central bank. It applies only in the case of a pooling system (i.e. one collateral pool per bank to secure all central bank credit operations; in an earmarking system, the value of the collateral posted is always very close to the outstanding credit). It is remarkable how the under-proportional use of Government bonds is relative to their share in the eligible assets. This reflects that in interbank repo markets, usually only Government bonds are accepted.

Posted assets	End-2009		
	Value (in bn euro)		% over total
Central Government	259		12.7%
Regional Government	72		3.5%
Covered bank bonds	274		13.4%
Corporate bonds	104		5.1%
Unsecured bank bonds	506		24.8%
ABS	502		24.6%
Other marketable assets	23		1.1%
Non-marketable (loans)	302		14.8%
Total	**2,041**		**100.0%**

It is interesting to compare these with a very simple aggregate euro area MFI balance sheet. It has to be assumed that the securities held are largely Eurosystem eligible. Again, the larger part of the securities will however not be "highly liquid" as defined by the regulation.

MFI aggregate balance sheet (end Dec. 2009, in trillions of euro; source: ECB monthly report)			
Assets		**Liabilities**	
Loans	**17.7**	**Deposits**	**16.5**
Securities	**5.0**	**Repos**	**0.3**
Of which:			
Government	*1.5*	**Debt securities issued**	**4.9**
Other euro area residents	*1.5*		
MFIs	*2.0*		
Rest	8.4	Rest	9.7
Total assets	31.1	Total assets	31.1

It is difficult for various reasons to draw firm conclusions from the data above on the impact of the new liquidity regulation. Still, the following is suggested by the data:

- For liquidity buffers of banks, central bank eligible assets that are not highly liquid (according to the LCR definition) play a key role.
- The differentiated treatment between "highly liquid" and "only central bank eligible" securities will have a huge impact, since the former is only a relatively small subset of the latter for the Eurosystem.

3.5 The central bank support during crisis time

In the previous section, we explained why banks have to rely on central banks during normal times to raise the necessary cash, as the liquidity deficit of the banking system vis-à-vis the central bank is

exogenous to decisions of the banks, and as the collateral framework of the central bank should be designed on the basis of an economic cost-benefit analysis. In this section, we provide a deeper normative analysis of why central banks should accept a broader range of collateral than the range accepted in interbank operations, and why the central bank should remain forthcoming towards its counterparties in a liquidity crisis when all private players take restrictive risk control measures. Some more light will thereby also be shed on moral hazard issues.

Before doing so, it is good to recall the rather clear 19th century conclusion about the supportive role of central banks, which has been seen in two variants. Both are famous, and nevertheless worth being recalled in the context of the new liquidity regulation. First, Jeremiah Harman, director of the Bank of England, summarized in a hearing of the Lords' Committee in 1832 the Bank's actions in the panic of 1825 as (found e.g. in Bagehot 1873):

> We lent… by every possible means, and in modes that we never had adopted before; we took in stock of security, we purchased Exchequer bills, we made advances on Exchequer bills, we not only discounted outright, but we made advances on deposits of bills to an immense amount; in short, by every possible means consistent with the safety of the Bank;… seeing the dreadful state in which the public were, we rendered every assistance in our power.

It is useful to note that the statement is about extra liquidity injection into the financial system at the benefit of all banks under circumstances of a collective financial market liquidity crisis, not about emergency liquidity assistance to individual banks (as often wrongly assumed). Harman explains the Bank of England's action as having been *creative and pro-active*, i.e. to have innovated to find the best ways to support funding liquidity of financial institutions, the only constraint to creativity being the need to preserve the "safety of the Bank".

The second famous view on central bank supportiveness from the 19th century central banking literature is due to Bagehot (1873) himself, and states the so-called "inertia principle" according to which the central bank should maintain its risk control framework at least inert, and accept an increase of the risk it takes in a crisis situation:

> If it is known that the Bank of England is freely advancing on what in ordinary times is reckoned a good security and on what is then commonly pledged and easily convertible, the alarm of the solvent merchants and bankers will be stayed. But if securities, really good and usually convertible, are refused by the Bank, the alarm will not abate, the other loans made will fail in obtaining their end, and the panic will become worse and worse.

In contrast to Harman, Bagehot does not emphasise the pro-active nature of the measures taken, but the fact that the central bank must remain "inert" and not tighten its risk control framework (e.g. by restricting the set of eligible collateral for advances), such as other market players would do.

In any case, it has been unquestioned central banker wisdom since the 19th century that the central bank must be supportive in a liquidity crisis. Today, probably as much as in the 19th century, three main reasons can be provided for a broad range of central bank collateral, and continued support during a financial crisis.

(1) **Negative social externalities of illiquidity** (and bankruptcy). The central bank should be ready to engage in measures supporting the funding liquidity of banks because of the potential negative externalities of bank stress and bank default. As a public player, it should have overall welfare in mind, i.e. encompass externalities. This argument has obviously a moral hazard dimension. Brunnermeier et al (2009) provide three reasons for financial regulation, of which the following would be "by far the most important": "where there are sufficient externalities that the social, and overall, costs of market failure exceed both the private costs of failure and the extra costs of regulation." They then review five types of externalities, of which they believe the following to be most important as a root cause to recent financial crisis: "In order to deal with such liquidity problems prior to failure, and in the course of liquidation after failure, the bank in difficulties will often be forced to sell assets (fire sales). But such sales will drive down the current market price of the same assets held on other banks' books, when these are valued on a mark-to-market basis. And, of course, the same is true the other way around; solvency is not exogenous to liquidity. When there is a generalised liquidity problem attempts to deal with it will lead to declines in asset values, creating a solvency problem, even where none existed before. In short, there is an internal amplifying process (liquidity spirals) whereby a falling asset market leads banks, investment houses, etc., to make more sales (deleveraging), which further drives down asset prices and financial intermediaries' assessed profit and loss and balance sheet net worth. We believe that it is this internal, self-amplifying dynamic that has lain at the root of both the recent, and virtually all prior, financial crises." Similarly, Perotti and Suarez (2010, 2) argue that "Because of fire sales or counterparty risk externalities, each bank's funding decision has an impact on the vulnerability of other banks, causing a negative externality… Because of the wedge between the net private value of short-term funding and its social cost, absent regulation banks will rely excessively on short term funding."

(2) The **central bank is the only economic agent not threatened by illiquidity in its own currency.** Central banks have been endowed with the monopoly and freedom to issue the legal tender: central bank money. Therefore, they are never threatened by illiquidity in their own currency and it seems natural (even from a purely commercial perspective) that, in case of a liquidity crisis when all agents price liquidity very high, the central bank remains more willing than others to hold (as collateral or outright) assets which are less liquid. This argument has nothing to do with negative externalities or with moral hazard. Even if the central bank were a commercially oriented enterprise, its exemption from liquidity stress should make it ready to take over illiquid positions in a crisis against a premium.

(3) **Haircuts are a powerful risk mitigation tool if credit risk is asymmetric and the cash taker (i.e. collateral provider) is more credit risky**. If, however, both the cash taker and the cash lender are both equally credit risky, then the power of haircuts is limited. Indeed, with haircuts, the cash taker is exposed to the risk of default of the cash lender, since, in case of such default, he is uncertain to get his collateral back. This is why haircuts between banks of similar credit quality tend to be low, while banks impose potentially high haircuts when they lend to e.g. hedge funds. This also explains why banks would never question haircuts imposed by the central bank, which can not default (see also Ewerhart and Tapking, 2008).

These three specificities together have lead to the conclusion that the central bank should play a special role in terms of collateral acceptance and liquidity provision in normal times and financial crisis. The three arguments should be counterbalanced against the one that there is no reason to expect the central bank to be very good in credit risk management, valuation, and in preventing to be sometimes tricked by counterparties who are at the brink of default and eventually default. Therefore, being too supportive may mean at the end to have central bank losses, i.e. an uncontrolled leakage of public resources to eventually defaulted entities. Or, it may require substantial spending of the central bank on collateral and risk management, also to over-compensate its comparative weaknesses in these activities. This has again a clear moral hazard dimension. Indeed, one could argue that as long as the central bank never makes losses, there is no real moral hazard issue, as funds are eventually not diverted to those who took non-prudent decisions.

The solutions to the two moral hazard issues could be as follows (see also section 6.4): *penalise excessive reliance on the central bank through surcharges* (thereby supporting the regulation), maintain a thorough and as needed expensive central bank risk management and collateral valuation framework, *and charge banks for the costs associated with the collateral they submit*. Both measures serve to internalise costs, and thereby to prevent moral hazard. The calibration of the fees charged to banks for the risk management of the collateral they submit seems relatively straightforward, as these should basically reflect costs. The calibration of surcharges for excess reliance is less obvious (see section 6.4).

The two measures would address two points already seen in the 19th century, namely preservation of "the safety of the [central] bank" (Hamann in 1832), and lending to banks under liquidity stress at a "high price" (Bagehot in 1872). The latter represents also an extra risk compensation. If these conditions are met, the central bank will not have a priori difficulties with the idea that it supports bank funding liquidity in normal and crisis times, which will be anticipated by banks and will reflect this in their liquidity risk management exactly explaining the necessity for the liquidity risk regulation to require banks to internalise the liquidity risks.

4. The impact of bank behaviour on the LCR and DFS

This section and the following one provide examples of key interactions between the new liquidity risk regulation and the central bank operational framework. In particularly, this section assesses how certain bank behaviour can impact the compliance with the LCR, can affect the LCR and DFS measure and have repercussions for central bank operations and central bank risks. More specifically, the section shows how interactions between both frameworks provide "arbitraging" opportunities of the liquidity risk regulation, which can have detrimental effects for monetary policy and regulation.
The analysis consists of some basic illustrative examples that show the impact of bank behaviour on the LCR and DFS measure.

- **"Distance to asset fire sales" (DFS)**: total amount of short term market funding evaporation that the bank can handle without fires sales of less liquid assets (as already introduced in section 3.3). In the following, we will consider examples of banks which will always have the same absolute balance sheet length, and therefore it does not matter to differentiate between relative and absolute measures.

To also reflect the impact of a closer alignment of the liquidity risk regulation with the central bank operations, the following two measures are used:

- **LCR*** = (non-encumbered Government bonds + cash + all non-encumbered central bank eligible assets applying central bank collateral haircuts) / (30 days cash outflows).
- **LCR**** = (non-encumbered Government bonds + cash + all non-encumbered central bank eligible assets applying central bank collateral haircuts) / (30 days cash outflows whereby applying a zero roll off for all central bank eligible securities)

LCR* includes in the nominator all non-encumbered central bank eligible assets, although applying as haircuts the one applied by the central bank. LCR** moreover assumes a zero roll off rate for all non-encumbered central bank eligible securities. These measures thus show the effect of a higher recognition of the impact the monetary policy operations on the LCR measure; but by definition lower the objectives of the regulation in terms of pricing liquidity risk by requiring firms to raise funding in markets on their own capacity (or to price their own capacity) and provide a buffer to absorb shocks. Additionally, it also reflects the notion underlying the regulation that central banks should not be the lender of "first" resort. As a result the liquidity risk regulation does not define the liquid assets as the central bank eligible collateral, the regulatory standards therefore can provide different indications than the measures that assess the probability of forced sales and systemic liquidity distress.

4.1 A first example

Consider as example the following three bank balance sheets.

Bank 1			
Government bonds	125	Long term market funding	100
A-rated corporate bonds	0	Short term unsecured market funding	100
CDOs	125	Long term central bank borrowing	50
		Short term central bank borrowing	0

Bank 2			
Government bonds	0	Long term market funding	100
A-rated corporate bonds	250	Short term unsecured market funding	100
CDOs	0	Long term central bank borrowing	50
		Short term central bank borrowing	0

Bank 3			
Government bonds	100	Long term market funding	100
A-rated corporate bonds	150	Short term unsecured market funding	100
CDOs	0	Long term central bank borrowing	50
		Short term central bank borrowing	0

Assume that the central bank accepts corporate bonds at a haircut of 10% (down to a BBB- rating, such as applied by the ECB). It also accepts Government bonds at a zero haircut, but does not accept at all CDOs. Of the assets considered in the example, the liquidity regulation only defines (non-encumbered) Government bonds as liquid assets. Additionally, as we define the short term unsecured market funding to be received from non-financial corporates a 75% run-off factor applies. Finally, notice that the above example shows the gross amounts of the balance sheet of the three banks. The following table provides the resulting liquidity measures for the three banks.

	Bank 1	Bank 2	Bank 3
DFS	75	175	155
LCR	1.00	0	1.3
LCR* = LCR**	1.00	2.33	2.5

The result is obtained that bank 1 fulfils the LCR (LCR=1) with a DFS of 75, while the second bank fails to fulfil the LCR (LCR = 0) but is much better in the DFS (at 175). This results from the fact that Bank 2 has an unused central bank borrowing potential of 175, and can therefore survive an outflow of its 100 of short term market funding before having to rely on asset fire sales. In contrast, Bank 1 may have to engage in asset fire sales of its CDOs when its short term funding outflows reach a certain level. The LCR* and LCR** measures are more aligned with the DFS measure in the sense that they have high and sufficient values for bank 2 (LCR* and LCR** are obviously identical as the central bank funding is all long term in the example chosen). This example illustrates the different information provided from the LCR and the DFS measures as indications of resilience to liquidity

stress. The DFS measure considers reliance on the central bank as good as reliance on market funding and provides an indication of the distance of banks from being forced to enter into asset fire sales and thereby trigger negative systemic externalities. The LCR measure was deliberately designed to provide an indication of the extent that the bank relies on its own capacities to raise funding.

Bank 3 performs best in terms of both the DFS and the LCR measure. It is interesting to note that this is the case although the bank has less highly liquid assets and the same liabilities as bank 1. This example illustrates that central bank eligibility of collateral is not at all irrelevant for the LCR in the sense that the existence of non-LCR-liquid but central bank eligible assets improves the LCR as it makes a higher share of the LCR-liquid assets non-encumbered. This clearly provides an incentive for banks to post illiquid assets at the central bank. Another illustration is as follows: if bank 1 would substitute its CDOs by corporate bonds (i.e. one type of non highly liquid assets by another), it would increase its liquid non-encumbered assets by 50, and its LCR accordingly to 1.67.

4.2 Effects on asset yields and central bank operations when the regulation is introduced

The following example assesses the changes that banks can make to comply with the regulation, consider the example of a system of financial accounts with two banks and one account representing the institutional investors' community in the economy. Assume that Government bonds in the initial equilibrium yield 1%, A-rated corporates 2%, CDOs 3%, and that central bank and market funding costs are 1%, such that banks are initially just profitable. The two banks are at the starting point, i.e. before liquidity regulation, both in competitive equilibrium in terms of profits (i.e. zero profit). Again, the central bank is assumed to accept corporate bonds with a haircut of 10% (but not CDOs). Finally it is assumed that investors are ready to change their asset composition, but that their marginal valuation decreases (increases) for each asset type by one basis point when holdings increase (decrease) by one unit of account.

Investors			
Government bonds	100	Equity	420
A-rated corporate bonds	100		
CDOs	100		
Short term deposits with banks	60		
Long term deposits with banks	60		

Bank 1			
Government bonds	100	Short term market funding	60
A-rated corporate bonds	0	Long term market funding	60
CDOs	100	Central bank borrowing 3M	40
		Central bank borrowing 1W	40

Bank 2			
Government bonds	50	Short term market funding	60
A-rated corporate bonds	100	Long term market funding	60
CDOs	50	Central bank borrowing 3M	40
		Central bank borrowing 1W	40

For the initial pre-regulation equilibrium, the value for the liquidity risk measures are displayed in the following table in columns 1 and 2. If the LCR is made binding, banks will have to take corrective actions to comply with it. Three possibilities are examined in the following examples.

I. **Amend the distribution of longer term central bank funding to the individual banks**. Bank 1 could take a larger share of the longer term funding from the central bank. If the long term funding is offered via a variable rate tender procedure, bank 1 could bid marginally more (a few basis points to be sure to get the desired share) and get the entire long term funding.[6] The results in the columns 3 and 4 of the following table show that there is only a negative impact on bank 2, and no positive one on bank 1. While this is a result from the specific example which should not be generalised (it reflects the fact that bank 1 was using highly liquid assets as collateral with the central bank, implying a zero run-off rate), this amendment would normally only have a limited impact in view of the low run-off rate assumed for short term central bank funding backed by LCR illiquid assets.

II. **Banks can buy government bonds from the other investors, and sell non-liquid assets**. If each bank takes 50 and in exchange sells 50 of its CDOs, both banks reach comfortable values of the LCR. However, banks turn out to be non-profitable in the example proposed, which is also not a desirable outcome. In practice, this of course depends on the interest elasticities of the other investors' demand for the various assets types. The higher the interest rate elasticities, the better this solution works.

III. **Banks can lengthen the duration of their market refinancing from investors**. Assume all of their market funding would become 3 months funding (and we also assume, somewhat artificially, that all funding would have a residual maturity of more than 1 month). Again, this easily achieves a sufficient LCR, but, under the assumptions taken in terms of interest rate elasticity of investors supply of funds at different maturities, again makes banks non-profitable.

The following table summarises the balance sheet positions of banks (first grey-shaded area of the table), the various bank liquidity measures and their components (subsequent non-shaded area; calculated on the basis of the raw bank balance sheet data, and the parameters set by regulators and central bankers), the investors' asset positions (second grey-shaded area) and finally the asset and liability remuneration rates and income associated with the various bank balance sheet positions. In the stylized example provided, the balance sheet changes made by the banks to comply with the liquidity risk regulation will be costly. These changes will potentially affect the yield curve and

[6] Note that in this paper, we always assume that "long term funding" such as three months funding has a residual maturity or more than one month, which is of course a simplification (assuming regular and granular overlapping refinancing operations, typically around one third of three months operations would have a residual maturity of less than one month).

spreads between various asset classes. However, the cost price will importantly be determined by the exchange or interaction with the other market participants / investors and with the central bank. Further work has to consider a more realistic interaction with the other market players. The effect of the central bank operations is shown in the next section.

	Initial scenario		Scenario I		Scenario II		Scenario III	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Bank 1	**Bank 2**	**Bank 1**	**Bank 2**	**Bank 1**	**Bank 2**	**Bank 1**	**Bank 2**
Bank assets								
Government bonds, CB debt certificates	100	50	100	50	**150**	**100**	100	50
corporate bonds		100		100		100		100
CDOs	100	50	100	50	50	0	100	50
Bank liabilities								
1 W market funding	60	60	60	60	60	60	**0**	**0**
3 M market funding	60	60	60	60	60	60	**120**	**120**
1 W CB funding	40	40	0	**80**	40	40	40	40
3 M CB funding	40	40	**80**	0	40	40	40	40
Liquidity measures								
Highly Liquid assets	100.0	50.0	100.0	50.0	150.0	100.0	100.0	50.0
Total CB borrowing	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Total CB borrowing potential	100.0	140.0	100.0	140.0	150.0	190.0	100.0	140.0
Total CB borrowing potential HL assets	100.0	50.0	100.0	50.0	150.0	100.0	100.0	50.0
Total CB borrowing potential non-HL assets	0.0	90.0	0.0	90.0	0.0	90.0	0.0	90.0
Total CB borrowing collater with non-HL assets	0.0	80.0	0.0	80.0	0.0	80.0	0.0	80.0
Total CB borrowing collater with HL assets	80.0	0.0	80.0	0.0	80.0	0.0	80.0	0.0
Total CB 1W borr collater with non-HL assets	0.0	40.0	0.0	80.0	0.0	40.0	0.0	40.0
Total CB 1W borr collater with HL assets	40.0	0.0	0.0	0.0	40.0	0.0	40.0	0.0
Non-encumbered highly liquid assets	20.0	50.0	20.0	50.0	70.0	100.0	20.0	50.0
Run off in one month	45.0	55.0	45.0	65.0	45.0	55.0	0.0	10.0
LCR	**0.4**	**0.9**	**0.4**	**0.8**	**1.6**	**1.8**	**-**	**5.0**
LCR *	0.4	1.1	0.4	0.9	1.6	2.0	-	6.0
LCR **	0.4	1.3	0.4	1.3	1.6	2.4	-	-
DFS	20.0	60.0	20.0	60.0	70.0	110.0	20.0	60.0
Investors' assets								
Gvt bonds	100		100		**0**		100	
Corporate bonds	100		100		100		100	
CDOs	100		100		**200**		100	
1W lending to banks	60		60		60		**0**	
3M lending to banks	60		60		60		**120**	
Asset yields								
Government bonds, CB debt certificates	1%	1%	1%	1%	0%	0%	1%	1%
Cash (deposits with CB)	1%	1%	1%	1%	1%	1%	1%	1%
corporate bonds	2%	2%	2%	2%	2%	2%	2%	2%
CDOs	3%	3%	3%	3%	4%	4%	3%	3%
1W Interbank lending	2%	2%	2%	2%	2%	2%	2%	2%
1 W market funding	2%	2%	2%	2%	2%	2%	2%	2%
3 M market funding	3%	3%	3%	3%	3%	3%	3.6%	3.6%
1 W CB funding	1%	1%	1%	1%	1%	1%	1%	1%
3 M CB funding	1%	1%	1%	1%	1%	1%	1%	1%
1W Interbank borrowing	2%	2%	2%	2%	2%	2%	2%	2%
Bank Income (yield * bank asset)								
Government bonds, CB debt certificates	1.0	0.5	1.0	0.5	0.0	0.0	1.0	0.5
Cash (deposits with CB)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
corporate bonds	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0
CDOs	3.0	1.5	3.0	1.5	2.0	0.0	3.0	1.5
1W Interbank lending	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bank funding cost (yield * liability)								
1 W market funding	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	0.0	0.0
3 M market funding	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-4.3	-4.3
1 W CB funding	-0.4	-0.4	0.0	-0.8	-0.4	-0.4	-0.4	-0.4
3 M CB funding	-0.4	-0.4	-0.8	0.0	-0.4	-0.4	-0.4	-0.4
1W Interbank borrowing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**0.2**	**0.2**	**0.2**	**0.2**	**-1.8**	**-1.8**	**-1.1**	**-1.1**

4.3 Two–sided central bank recourse, "adverse selection" and crowding-out

The following example considers a bank funding central bank deposits through central bank borrowing backed by LCR illiquid assets.

Bank			
Government bonds	100	Long term market funding	20
A-rated corporate bonds	200	Short term market funding	200
Deposits with central bank	π	Central bank borrowing 3M	80 + π

In the initial condition the bank has an LCR of 0.7. Interestingly, though, it can increase its LCR by demanding extra cash from the central bank (in this example through 3-month central bank repo transaction) and holding it as deposit with the central bank. The table below shows this effect as the parameter π (proportion of additional central bank funding and central bank deposit) in the bank balance sheet is varied accordingly.[7]

	1	2	3	4	5	6
Bank assets						
Government bonds, CB debt certificates	100	100	100	100	100	100
Cash (deposits with CB) = π		**20**	**40**	**60**	**80**	**100**
corporate bonds	200	200	200	200	200	200
Bank liabilities						
1 W market funding	200	200	200	200	200	200
3 M market funding	20	20	20	20	20	20
3 M CB funding	80	**100**	**120**	**140**	**160**	**180**
Liquidity measures						
Highly Liquid assets	100.0	120.0	140.0	160.0	180.0	200.0
Total CB borrowing	80.0	100.0	120.0	140.0	160.0	180.0
Total CB borrowing potential	280.0	280.0	280.0	280.0	280.0	280.0
Total CB borrowing potential HL assets	100.0	100.0	100.0	100.0	100.0	100.0
Total CB borrowing potential non-HL assets	180.0	180.0	180.0	180.0	180.0	180.0
Total CB borrowing collater with non-HL assets	80.0	100.0	120.0	140.0	160.0	180.0
Total CB borrowing collater with HL assets	0.0	0.0	0.0	0.0	0.0	0.0
Total CB 1W borr collater with non-HL assets	0.0	0.0	0.0	0.0	0.0	0.0
Total CB 1W borr collater with HL assets	0.0	0.0	0.0	0.0	0.0	0.0
Non-encumbered highly liquid assets	100.0	120.0	140.0	160.0	180.0	200.0
Run off in one month	150.0	150.0	150.0	150.0	150.0	150.0
LCR	**0.7**	**0.8**	**0.9**	**1.1**	**1.2**	**1.3**
LCR *	1.3	1.2	1.1	0.9	0.8	0.7
LCR **	1.3	1.2	1.1	0.9	0.8	0.7
DFS	200.0	200.0	200.0	200.0	200.0	200.0

The bank can increase its LCR linearly by 0.1 with each 20 of extra central bank funding it takes for depositing with the central bank. The attractiveness of doing so of course depends on how desperate the bank is in its search for ways to comply with the LCR, and what costs arise with this technique, as central banks normally apply an interest rate spread between lending operations and deposit collection. For instance the Eurosystem currently applies a spread of 75 basis points, while other central banks foresee a more narrow spread of e.g. 25 basis points. However, for banks in desperate need to reduce any liquidity shortfall, these spreads will not be prohibitive. The incentive to perform these kind of

[7] The table is in structure in principle like the previous example, although the investors' assets and the remuneration rates of assets and liabilities are no longer of interest (as they do not change).

operations will also depend on the actual implementation of the liquidity risk regulation (e.g. the number of times that supervisors monitor the ratios).

In any case, it should be noted that the spread might not necessarily be detrimental to banks to perform these kinds of operations, as an increase of borrowing by an LCR constrained bank can also be achieved through a **refinancing substitution channel**. Consider the case of the following two banks.

Bank 1			
Government bonds	100	Long term market funding	20
A-rated corporate bonds	200	Short term market funding	200
		Central bank borrowing 3M	80

Bank 2			
Government bonds	100	Long term market funding	170
A-rated corporate bonds	200	Short term market funding	50
		Central bank borrowing 3M	80

Bank 1 is identical to the initial bank in the previous example, and thus, again, does achieve an LCR of only 0.7 (see column 1 of the following table). Bank 2 is an exemplary bank with a high share of long term funding which already initially fulfils the LCR with a value of 2.7 (see column 2 of the following table). Bank 1 can actually achieve compliance with the LCR **by crowding out bank 2 from central bank refinancing**. This works at low cost for bank 1 if bank 2 has no problems to refinance in the market at short term, i.e. if it has an excellent credit rating and therefore is not constrained in its market funding. Then, bank 1 can bid somewhat more aggressively in the (assumed) variable rate tenders for 3 months funds, and bank 2 will conclude that competing for central bank funding is not attractive under these circumstances, and will instead go to the market. In the example chosen (see columns 3 and 4 in the table below), bank 1 crowds out bank 2 completely, and both banks will eventually achieve a compliant LCR. The central bank will however have seen the weighted average credit quality of its counterparties decrease, and its concentration risk increase. Also, the true liquidity situation of the banks has not really improved. Hence, to comply with the regulation weaker banks (in terms of capital and liquidity positions) will be incited to rely even more heavily on the central bank funding[8], thereby using illiquid collateral (see also Eisenschmidt and Holthausen, 2011 and van den End, 2010). This will affect the overall risk taking of the central bank.

[8] This effect is of course already present outside the introduction of the liquidity regulation.

	Bank 1	Bank 2	Bank 1	Bank 2
	1	**2**	**3**	**4**
Bank assets				
Government bonds, CB debt certificates	100	100	100	100
Cash (deposits with CB) = π				
corporate bonds	200	200	200	200
Bank liabilities				
1 W market funding	200	50	**120**	**130**
3 M market funding	20	170	20	170
3 M CB funding	80	80	**160**	**0**
Liquidity measures				
Highly Liquid assets	100.0	100.0	100.0	100.0
Total CB borrowing	80.0	80.0	160.0	0.0
Total CB borrowing potential	280.0	280.0	280.0	280.0
Total CB borrowing potential HL assets	100.0	100.0	100.0	100.0
Total CB borrowing potential non-HL assets	180.0	180.0	180.0	180.0
Total CB borrowing collater with non-HL assets	80.0	80.0	160.0	0.0
Total CB borrowing collater with HL assets	0.0	0.0	0.0	0.0
Total CB 1W borr collater with non-HL assets	0.0	0.0	0.0	0.0
Total CB 1W borr collater with HL assets	0.0	0.0	0.0	0.0
Non-encumbered highly liquid assets	100.0	100.0	100.0	100.0
Run off in one month	150.0	37.5	90.0	97.5
LCR	**0.7**	**2.7**	**1.1**	**1.0**
LCR *	1.3	5.3	1.3	2.9
LCR **	1.3	5.3	1.3	2.9
DFS	200.0	200.0	120.0	280.0

5. Central bank operations and banks' compliance with the liquidity risk regulation

The previous section showed that certain central bank operations can provide "arbitraging" opportunities of the liquidity risk regulation. This section reviews how central bank policies influence the ability of banks to comply with the new liquidity risk regulation. The last subsection puts the findings in an international context and shortly discusses the challenges of obtaining an international level playing field regarding the implementation of the liquidity risk regulation.

5.1 Collateral eligibility

This first example illustrates the importance of collateral eligibility, which was already touched upon in the previous section.

Bank 1			
Government bonds	100	1W market funding	60
A-rated corporate bonds	0	3M market funding	60
CDOs	100	Central bank borrowing 3M	80

Bank 2			
Government bonds	50	1W market funding	60
A-rated corporate bonds	100	3M market funding	60
CDOs	50	Central bank borrowing 3M	80

Collateral eligibility has no representation in the banks' balance sheets, as it concerns the status given to certain asset side balance sheet positions of banks. In our simple examples, the central bank may specifically consider whether or not to accept corporate bonds and CDOs as collateral, and at what haircut.

The table below summarises the results for different eligibility decisions and values of haircuts chosen by the central banks. Of course, the value of haircuts does not appear itself as a pure policy measure. It should be derived to ensure sufficient risk protection of the central bank, namely such that the expected loss from a certain quantity of CDOs used as collateral is similar to the expected loss to the central bank from the use by banks of other types of central bank collateral (see section 3). The following policy scenarios are distinguished:

I. Narrow collateral set: only accept Government bonds as collateral.

II. Intermediate collateral set: accept Government bonds and A-rated corporate bonds at a haircut of 10%.

III. Broad collateral set: accept Government bonds, A-rated corporate bonds at a haircut of 10%, and CDOs at a haircut of 25%.

The table below presents the results for the two banks in terms of DFS and LCR measures. Under the intermediate approach (II), which is the one that had been assumed in previous examples, bank 1 is non-compliant with the LCR, but bank 2 is compliant, thanks to the indirect effects of corporate bonds being used for central bank refinancing, which makes that all Government bonds are non-encumbered. Under the narrow approach (I), bank 1 is unchanged in terms of LCR, but bank 2 is constrained and even needs to reduce its central bank funding (and increase short term market funding) as it no longer has sufficient collateral. Its LCR is zero, and so is its DFS. Under the broad collateral set, both banks have a compliant LCR, thanks to the effect that all Government bonds remain non-encumbered as other assets can collateralise central bank borrowing.

	collateral set		
	I. narrow	II. medium	III broad
Bank 1			
LCR	0.4	0.4	2.1
DFS	20	20	95
LCR*	0.4	0.4	2.1
LCR**	0.4	0.4	2.1
Bank 2			
LCR	0*	1.1	1.1
DFS	0*	60	97.5
LCR*	0*	1.3	2.2
LCR**	0*	1.3	2.2

* after substituting central bank funding which can no longer be collateralised with short term market funding

As already shown in the previous section, these results confirm again that central bank eligibility is far from irrelevant under the new liquidity regulation. However, its impact is not that obvious, as it depends on the way in which the amount of non-encumbered highly liquid assets is affected. Therefore, defining an international fixed set of liquid assets underlying the LCR measure in a context of different central bank policies clearly does not provide a level playing field across jurisdictions.

5.2 Change maturity of central bank refinancing operations

The LCR regulation makes a distinction between short term (30-days and less) and longer term central bank funding, and more specifically short term central bank funding collateralised with non-highly liquid assets receives a run-off rate of 25% (short term funding collateralised with highly liquid assets, receives a run-off factor of zero). Therefore, the maturity of funding provided by the central bank is relevant (as long term central bank funding will have a zero run-off, if not maturing within a one month horizon). Call λ the share of short term operations, and thus $(1-\lambda)$ the share of long term operations offered by a central bank, and assume the following representative bank.

Bank			
Government bonds	100	Short term market funding	100
A-rated corporate bonds	100	Central bank borrowing 3M	100.(1- λ)
		Central bank borrowing 1W	100. λ

	Share of long-term central bank operations		
	I. λ=1	II. λ=0.5	III. λ=0
Bank 1			
LCR	0.9	1.1	1.2
DFS	90	90	90
LCR*	0.9	1.1	1.2
LCR**	1.2	1.2	1.2

Again, the example clearly shows the influence of the central bank decisions on the fulfilment of the LCR by the banks. In this case, increasing the share of long term reverse operations facilitates the compliance of banks of the LCR standard.

5.3 Outright purchases of securities from banks

The next example considers the impact of outright purchases of securities by the central bank. For this, the central bank's balance sheet is introduced, which has the following initial form, with a=b=c=0 indicating that the central bank has initially no outright holdings of securities.

Central bank			
Central bank 3M- lending	200-a-b-c	Banknotes in circulation	200
Government bonds	a		
A-rated corporate bonds	b		
CDOs	c		

When the central bank purchases assets, it always does so via the banks. However, the banks can be assumed to adjust to some extent through transactions with end investors. For three reasons, the equilibrium after the purchases will not be the same as the one before the start of the purchases: first, relative asset prices and yields change; second, the liquidity deficit of the banks vis-à-vis the central bank diminishes; third, compliance with the liquidity regulation will change, which may trigger corrective action. Assuming that the central bank purchases proportionally from the two banks according to their initial positions in the respective security, the following changes occur to the assumed banks' balance sheets.

Bank 1			
Government bonds	100 - 2/3 a	Short term market funding	100
A-rated corporate bonds	0	Central bank borrowing 3M	100 – 2(a+c)/3
CDOs	100 – 2/3 c		

Bank 2			
Government bonds	50 –1/3 a	Short term market funding	100
A-rated corporate bonds	100 - b	Central bank borrowing 3M	100 – (a+2b+c)/3
CDOs	50 –1/3 c		

Now we can calculate how the LCRs of the two banks evolve as a function of a, b, and c. We consider the following five scenarios:

I. The central bank purchases 100 Government bonds.

II. The central bank purchases 100 corporate bonds.

III. The central bank purchases 100 of CDOs. It may be noted that the purchasing of CDOs is in principle equivalent to the central bank purchasing foreign reserves from domestic banks.

IV. The central bank purchase 100 of corporate bonds and 100 of CDOs. In this case, short term market funding must migrate from bank 2 to bank 1, as otherwise bank 1 would be in a liquidity surplus. The balance sheets of the system will take the following form:

Central bank			
Central bank 3M- lending	0	Banknotes in circulation	200
Government bonds	0		
A-rated corporate bonds	100		
CDOs	100		

Bank 1			
Government bonds	100	Short term market funding	133.3
A-rated corporate bonds	0	Central bank borrowing 3M	0
CDOs	33.3		

Bank 2			
Government bonds	50	Short term market funding	66.6
A-rated corporate bonds	0	Central bank borrowing 3M	0
CDOs	16.6		

V. The central bank purchases 100 of each of these three types of securities. As in this case the banking system ends in a liquidity surplus, therefore it is assumed that the central bank issues debt certificates to extract the excess liquidity. Central bank debt certificates are eligible collateral for central bank borrowing (including in the marginal lending facility), and the same haircuts apply as for Government bonds (namely zero in the present example). Central bank debt certificates are also recognised by the new liquidity regulation as highly liquid assets. The following system of accounts assumes that the debt certificates are purchased equally by the two banks.

Central bank			
Central bank 3M- lending	0	Banknotes in circulation	200
Government bonds	100	Debt certificates issued	100
A-rated corporate bonds	100		
CDOs	100		

Bank 1			
Government bonds	33.3	Short term market funding	116.6
A-rated corporate bonds	0	Central bank borrowing 3M	0
CDOs	33.3		
Debt certificates	50		

Bank 2			
Government bonds	16.6	Short term market funding	83.3
A-rated corporate bonds	0	Central bank borrowing 3M	0
CDOs	16.6		
Debt certificates	50		

The following table summarises the LCR and DFS outcomes of various outright holdings of the central bank in the three types of financial assets.[9]

[9] It should be noted that the 1 month cash outflow in all of these examples is 0.75 * 120 = 90. Therefore LCR* = LCR ** = DFS / 90.

	1	2	3	4	5	6	7	8	9	10	11	12
	base case		**I. a=100**		**II. b=100**		**III. c=100**		**IV. b=c=100**		**V. a=b=c=100**	
	Bank 1	Bank 2	Bank 1	Bank 2	Bank 1	Bank 2	Bank 1	Bank 2	Bank 1	Bank 2	Bank 1	Bank 2
Bank assets												
Government bonds, CB debt certificates	100	50	**33.3**	**16.6**	100	50	100	50	100	50	**83.3**	**66.6**
corporate bonds		100	0	100		**0**		100		**0**		**0**
CDOs	100	50	100	50	100	50	**33.3**	**16.6**	**33.3**	**16.6**	**33.3**	**16.6**
Bank liabilities												
1 W market funding	100	100	100	100	100	100	100	100	**133.3**	**66.6**	**116.6**	**83.3**
3 M market funding	0	0			0	0	0	0	0	0	0	0
1 W CB funding	0	0			0	**0**	0	0	0	0	0	0
3 M CB funding	100	100	**33.3**	**66.6**	100	0	**33.3**	**66.6**	**0**	**0**	**0**	**0**
Liquidity Measures												
Highly Liquid assets	100.0	50.0	33.3	16.6	100.0	50.0	100.0	50.0	100.0	50.0	83.3	66.6
Total CB borrowing	100.0	100.0	33.3	66.6	100.0	0.0	33.3	66.6	0.0	0.0	0.0	0.0
Total CB borrowing potential	100.0	140.0	33.3	106.6	100.0	50.0	100.0	140.0	100.0	50.0	83.3	66.6
Total CB borrowing potential HL assets	100.0	50.0	33.3	16.6	100.0	50.0	100.0	50.0	100.0	50.0	83.3	66.6
Total CB borrowing potential non-HL assets	0.0	90.0	0.0	90.0	0.0	0.0	0.0	90.0	0.0	0.0	0.0	0.0
Total CB borrowing collater with non-HL asset	0.0	90.0	0.0	66.6	0.0	0.0	0.0	66.6	0.0	0.0	0.0	0.0
Total CB borrowing collater with HL assets	100.0	10.0	33.3	0.0	100.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0
Total CB 1W borr collater with non-HL assets	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total CB 1W borr collater with HL assets	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-encumbered highly liquid assets	0.0	40.0	0.0	16.6	0.0	50.0	66.7	50.0	100.0	50.0	83.3	66.6
Run off in one month	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	100.0	50.0	87.5	62.5
LCR	**0.0**	**0.5**	**0.0**	**0.2**	**0.0**	**0.7**	**0.9**	**0.7**	**1.0**	**1.0**	**1.0**	**1.1**
LCR *	0.0	0.5	0.0	0.5	0.0	0.7	0.9	1.0	1.0	1.0	1.0	1.1
LCR **	0.0	0.5	0.0	0.5	0.0	0.7	0.9	1.0	1.0	1.0	1.0	1.1
DFS	0.0	40.0	0.0	40.0	0.0	50.0	66.7	73.4	100.0	50.0	83.3	66.6

The example shows that outright operations by central banks of the regulatory illiquid assets can have a strong influence on the fulfilment of the liquidity coverage ratio, although the impact depends on the initial positions of banks in the relevant assets. In the central bank purchase case I (a=100), bank 2 is even made worse off in terms of LCR (compare column 2 and 4). There is however a small improvement of bank 2's LCR in scenario V compared to scenario IV (the two scenarios differ, again, by an extra purchase of 100 of Government bonds by the central bank).

It is important to retain that outright asset purchases tend to be supportive in terms of bank liquidity buffers if they focus on the less liquid assets, i.e. those not even accepted by the central bank, but that effects are overall heterogeneous across banks.

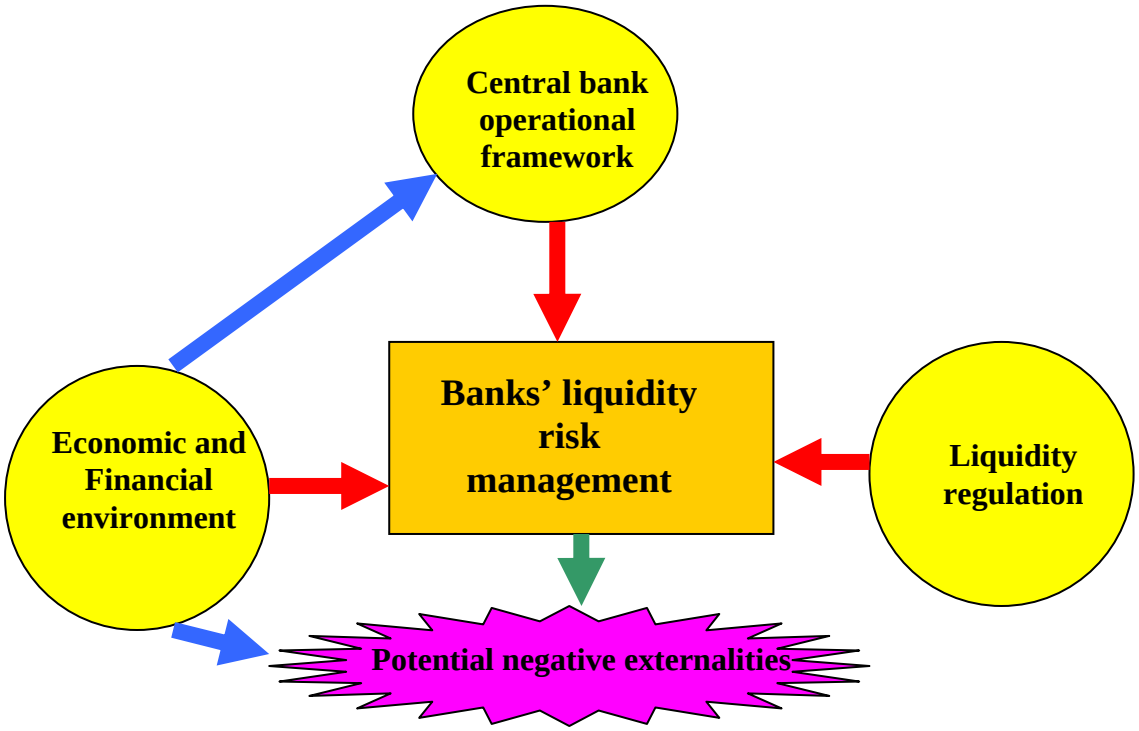
Outright purchases as a central bank tool would be influenced by the extent that banks rely on liquid assets to absorb shocks. As shown by van den End (2010), since banks with a relatively high share of liquid assets depend more on developments in the markets. This would imply that "central banks increasingly may have to resort to asset purchases in stead of refinancing operations to influence banks' liquidity position".

5.4 The international liquidity level playing field

The examples above show that an internationally harmonised liquidity risk regulation with differing central bank operational and collateral frameworks does not allow for a level playing field for banks. While on the one hand, compared to the patchwork of regulation and supervision that consisted before the introduction of the regulation, the supervision of course will become more harmonised, on the

other hand a full-fledged level playing field will not be obtained if one does not control for the central bank operations.

Eventually, a level playing field would only be achievable if the entire external environmental to the banks would be identical, which of course has never been achieved and will never be achieved. One could of course desire that *central banks* contribute more to a level playing field by converging in terms of operational frameworks. However, this would need to take into account that already now central bank operational frameworks reflect at least partially differences in the financial and economic environment (see e.g. Tabakis and Weller 2009 or Chailloux et al 2008 for comparisons of collateral frameworks, including the question of whether or not differences can be explained as reflecting different environments in an optimal way, or simply history and random choices). The figure below illustrates the issue. Only when the "sum" of the environment and the operational framework are identical with regard to their impact on banks, then also a prescriptive global liquidity risk standard would obviously be in line with maintaining a level playing field. If the environment is heterogeneous across countries, then it is no longer obvious to what extent and how a level playing field can and should be reached.



One may also ask in this context what measure may be desirable for central banks to take to increase the resilience of banks to liquidity shocks. A general answer to this question probably cannot be given. The following dimensions may give orientation:

- Does the central bank's changes of its operational framework support true resilience against liquidity shocks, i.e. does it truly contribute to enhancing the shock absorbance and reducing

negative externalities of banks' liquidity stress in a financial crisis, or does it only contribute to the formal fulfilment of the liquidity standards?

- Does it seem to be fair in terms of a level playing field and does it support convergence of operational frameworks, or does it appear as creating a privileged situation for domestic banks?
- Does it have drawbacks in terms of other objectives of the operational framework? Assuming that the operational framework was optimal before the introduction of new liquidity standards, to what extent could changes which are inspired by the introduction of the LCR lead to a loss of achievement of the other objectives of the central bank operational framework, such as an effective monetary policy implementation, efficiency, transparency and simplicity, limitation of central bank risk taking, etc.?

General conclusions cannot be drawn without a more thorough analysis of each specific issue envisaged.

6. Addressing the interactions between the liquidity risk regulation and the CB operational framework

6.1 Interactions between the liquidity risk regulation and CB operational framework

The examples provided in previous sections show that the liquidity risk regulation and the central bank operational framework strongly interact. These interactions are not necessarily positive from a monetary policy and financial stability perspective. The "arbitrage" opportunities of the liquidity risk regulation through central bank operations can have a number of detrimental effects:

- They may undermine the effectiveness of the liquidity risk regulation and imply that the regulation's purpose of internalizing liquidity risks and building adequate liquidity buffers that must enable the firm to raise on their own capacities the necessary funding in the financial markets during stress is not achieved.

To comply with the regulation, weaker banks (in terms of capital and liquidity positions) will be incited to rely even more heavily on the central bank funding, using illiquid collateral[10]. This increases average counterparty risk, concentration risk, and overall financial risk taking of the central bank.Monetary policy implementation may possibly be affected through various other effects, such as more aggressive and volatile bidding behavior in open market operations, recourses to central bank standing facility not relating to aggregate liquidity conditions, structural changes to the yield curve and

[10] The effect of a higher reliance on central bank funding by weaker banks is an effect already present without the liquidity risk regulation.

to spreads between various instruments which change the transmission mechanism of monetary policy, etc. (these aspects are not analyzed further in the present paper)

Central bank operations clearly will affect the extent in which banks will be able to comply with the regulation. Policies will have to be developed with regard to how central banks should take into account this fact when deciding on changes to their operational framework and the use of their instrument. The effectiveness of the regulation should not be undermined through monetary policy implementation. This, together with the unequal international level playing field in terms of central bank operational frameworks and their impact on the ability to comply with the LCR, emphasizes the necessity of further analysis and policy development. In particular, further study should consider the development of a framework that, in obtaining a specific monetary policy during normal times, determines the optimal central bank operational framework but remains in some sense "neutral" (not supportive and not detrimental) to banks for their compliance with the liquidity risk regulation.

6.2 Their distinctive purposes

In view of the important interactions between the liquidity risk regulation and the central bank operational framework, the two cannot be treated in isolation. Implementing the regulation as shown can have important effects on the central bank operations and, vice versa, the central bank operational framework (and modifications) will have important effects on the extent that banks can comply with the regulatory requirements.

These interactions though do not argue for a complete alignment of the regulatory and central bank operational framework. An example of such an alignment would, for instance, be the acceptance of all central bank eligible assets (at equivalent haircuts) as highly liquid assets with a full roll-over of the central bank refinancing. These kinds of alignments have been voiced as solutions to the interactions between both frameworks. However, such kinds of approaches would undermine the purpose of the regulation (i.e. liquidity risk pricing and the building of market based liquidity buffers). Therefore, the regulatory and central bank framework have to remain separate to recognize their respective purposes and not to lose the effectiveness of their functions.

To appropriately address any negative interactions between both frameworks it will be of utmost importance that supervisory authorities and central banks closely cooperate. The cooperation will have to consist of, first, a careful identification of any potential negative interactions. The paper provides some examples of interactions; however, there probably are many others to consider (also provided the changing market and economic conditions). A second element of the cooperation will have to consist of taking appropriate actions (both in terms of central bank operations and regulation/supervision) to deal with the negative interactions.

The assessment of the interactions and the decision on the appropriate actions will be complicated by the potential non-linear affects of the interactions and the different impact of the interactions on the individual banks.

6.3 Possible changes of the central bank monetary policy implementation framework?

6.3.1 Central banks could tighten collateral eligibility

Central banks accepting a wide collateral set, such as the Eurosystem, could reduce the acceptance of non-liquid assets (such as idiosyncratic ABS structures and credit claims), and the "self-use" of collateral, i.e. the use as collateral of self-originated ABS and self-issued covered and structured covered bonds. The latter change, i.e. accepting only securities issued by non-related entities would ensure a higher degree of liquidity of central bank eligible assets, as obviously these assets would have a minimum degree of tradability and would always have been traded at least once (as they are owned by a bank who has not issued or originated them). This would already reduce the "arbitraging possibility" that banks would experience under the wide collateral framework and would raise the internalization of the liquidity risks.

6.3.2 Central banks could differentiate between liquid and non- liquid assets in their operations

The Fed has traditionally allowed a much wider collateral set for discount window operations than for its reverse open market operations (see Tabakis and Weller, 2009). The Bank of England has introduced in 2010 two distinct sets of collateral, one liquid, one less liquid, and conducted longer term operations for both sets in parallel, resulting in a higher interest rate for the less liquid collateral set (see Bank of England, 2010). In general, the creation of separated collateral pools allows the central bank to apply various forms of discrimination against the less liquid collateral set, also in a way to limit the arbitraging of the differences between central bank operations and the new liquidity regulation. If this is one of the purposes of differentiated collateral sets, then of course, ideally, the sets could be more closely aligned with the sets established by regulators (level 1, level 2, non-liquid).

6.3.3 Central banks could strengthen financial disincentives against over-reliance on the central bank

To support the objectives of the regulation, central banks could tackle any excessive reliance of banks on the central bank through price disincentives. For instance the IMF has been using for a long time surcharges depending on proportionality of the loans relative to the country quotas for its various facilities (See e.g. IMF 2008).

This approach would help regulators in addressing the issue of over reliance of individual banks on central banks and would be in line with Bagehot's advice to "lend freely, but at a high price" in a crisis. An additional approach through which the central bank could address over reliance via its

operational framework, would be to define cost covering fees for the valuation and risk management of less liquid assets that are submitted to the central bank as collateral. While it can be justified that central banks accept less liquid assets as collateral than the assets accepted in interbank repos (see section 3), it will lead to distortions if the central bank would not perform a thorough risk and valuation analysis of these assets, or if it does so, but does not charge the banks submitting the collateral for that analysis. Therefore, as a second even more obvious element of price incentives against undue reliance on the central bank, the central bank could charge the banks the costs associated with the acceptance of less liquid (and hence normally more complex) assets.

6.4 The regulation could accept a wider set of liquid assets but with a general extra haircut

The regulation could in principle[11] consider a wider set of liquid assets and apply general extra haircuts (above the central bank haircuts) to all such assets except for government paper of high credit quality and liquidity. The size of the extra haircut could be an expression of the regulator's assessment of the potential liquidity value of the assets on the financial markets during the considered regulatory stress.

It should be noted that central banks have rarely restrained collateral eligibility during the recent financial crisis.[12] This does not mean that they did not adjust downwards collateral values in line with some mark-to-market (or mark-to model) valuation. Therefore, extra haircuts could in addition capture the effects of a stress on the availability of central bank funding. Empirical analysis of the asset value behavior during recent crises could provide required insights in determining the appropriate haircuts.

A wider set of liquid assets with more granular haircuts would also reduce the cliff effects that are currently present in the regulation (through the current binary categorization between liquid and illiquid assets), this would benefit the resilience of the financial system.

7. Conclusions

This paper shows the importance of interactions between the new liquidity risk regulatory framework and monetary policy operational framework of central banks. It describes how central banks play a crucial role in the liquidity provision to banks in normal times and in a financial crisis. The paper further provides the reasoning behind the liquidity risk regulation and its objectives. It is noted that the liquidity risk regulation, to achieve its purpose and being an international rule, cannot be fully aligned with the operational frameworks of individual central banks. The paper provides some clear examples of interactions between the two frameworks that affect the extent that banks comply with the regulation and effect the central bank operational framework. These interactions though do not argue

[11] We refer to section 6.4, the Basel III liquidity risk rules are set at an international level, however, the central bank collateral framework (e.g. collateral eligibility) are a reflection of the particular economic and banking landscapes.

[12] During the financial crisis that started in 2007, in fact almost all central banks widened their collateral set.

for a complete alignment of the regulatory and central bank operational framework; the liquidity risk regulation and the central bank operational framework have to be treated distinctively to recognize their respective purposes and not to lose the effectiveness of their functions. However, to appropriately address any negative interactions between both frameworks, close cooperation between supervisory authorities and central banks will be of utmost importance. Cooperation will have to consist of, first, a careful identification of any potential negative interactions and, second, taking appropriate actions to deal with the negative interactions. Some general and preliminary examples of measures are provided that could (partly) address some of the illustrated negative interactions. The paper also advances the use of a second measure, namely the distance to fire sales, to assess the resilience of banks to liquidity shocks and to assess the probability of negative externalities through fire sales.

Underlying the new regulation is the assumption that the firm in first instance should rely on its own capacity to raise funding in the financial markets and not to rely on central bank funding. Through this assumption the regulation seeks to require banks to internalize or price their liquidity risk. However this assumption necessitates a clear qualification as the concept of the liquidity deficit of the banking system vis-à-vis the central bank is of relevance, since it explains the banks' funding dependence on the central bank at the aggregate, macro-economic level. This structural dependence of banks on the central bank is exogenous to the decisions of banks. The latter has partially a moral hazard dimension[13], but also reflects "technological" specificities of the central bank (not being subject to liquidity risk in its own currency, and being able to apply the haircut instrument effectively). In addition, central banks have a clear economic rational to play the exceptional role of liquidity provider during a liquidity crisis.

To show the interaction between the new liquidity risk regulation and monetary policy, an additional measure of liquidity stress is introduced; the distance to fire sales (DFS). The DFS gives an indication of the total amount of short term market funding evaporation that the bank can handle without having to rely on fire sales of less liquid assets. Starting from various stylized bank balance sheet examples, the ability of banks to comply with the LCR and the alternative measures of liquidity is analyzed, and examples are given in which the LCR and DFS provide clearly different insights. The examples show the necessity to use both measures to assess the resilience of the banks and wider banking sector. Provided their different objectives, the LCR measure is of more relevance as liquidity measure during normal market conditions; to require banks to price their liquidity risks. However, it loses its relevance the stronger the liquidity stress as during these periods the liquidity buffer should help in absorbing the liquidity shock. In addition, during these stressed conditions the DFS becomes more relevant as one wants to know the extent that a bank is from having to rely on fire sales to cover short-term funding market outflows.

[13] Namely that the central bank has public welfare in mind, and therefore will not punish those who were reckless in terms of liquidity risk management at the expense of the community, but may support them when needed for the sake of avoiding negative externalities of illiquidity. However, this shows the necessity of a liquidity risk regulation.

The stylized examples show some of the clear interactions between the liquidity risk regulation and the central bank operational framework. These interactions, however, can be negative from a monetary policy and financial stability perspective. The examples considered show that the interactions can provide "arbitraging" opportunities through the central bank operations of the liquidity risk regulation. This can have detrimental effects as it would undermine the effectiveness of the regulation. It could affect the financial risk taking of the central bank and could affect the monetary policy implementation. In addition, central bank operations will clearly affect the extent that banks will be able to comply with the regulation. Policies will have to be developed with regard to how central banks should take into account this fact when deciding on changes to their operational framework and the use of their instrument. The effectiveness of the regulation should not be undermined through monetary policy implementation. Therefore, a framework has to be developed that, to obtain a specific monetary policy during normal times, determines the most optimal central bank operations but remain "neutral" (not supportive and not detrimental) to banks for their compliance with the liquidity risk regulation.

These interactions do not argue for a complete alignment of the regulatory and central bank operational framework, since the purpose of the regulation (i.e. liquidity risk pricing and the building of liquidity buffers not relating to the central bank) would be completely lost. Therefore, the respective frameworks of the regulation and the central bank have to remain separate as to recognize their respective purposes and not to lose the effectiveness of their functions.

The paper provides a few proposals to address some of the negative interactions:

First, central banks could support the regulatory efforts to reduce reliance of banks on the central banks and ensure that banks price the liquidity risks of their activities thereby revisiting their collateral framework. Central banks with a wide collateral set may consider whether this should not imply a gradual narrowing of the collateral set, or of certain self-use practices. *Second*, central banks could study if they cannot introduce appropriate price disincentives against excessive reliance of banks on them, such as a stepwise increasing surcharge for disproportionate borrowing. This could support regulators, would take up Bagehot's advices, and would also support central bank exposures to remain granular and diversified, i.e. would be in the interest of central bank risk management. *Third*, central banks must ensure that the less liquid, and hence normally more complex assets they accept, are thoroughly valued and assessed, such as to identify all associated risks. The costs associated with this task should be charged to the banks submitting the collateral. Otherwise, an excessive reliance of banks on central bank funding with the least liquid collateral will be the result (a sort of Gresham's law for collateral), which may indeed be associated with the term moral hazard.

However, further work has to elaborate on the potential appropriate proposals. In general, a close cooperation will be required between supervisory authorities and central banks to address negative

interactions between the central bank operational frameworks and the regulation. We would therefore only partially agree with Jesper Berg (2010) who argues, "Liquidity standards and central bank collateral rules are two sides of the same coin. Ignoring this is not sustainable. To the many impossibilities in economics is added a new one…" – they are closely related concepts but that does not imply that they are identical and have identical purposes. Still, he is right that one cannot ignore the interactions and the need to develop policies with their regard.

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