Can banks use their liquid asset buffers?[1]

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Preliminary draft, please do not circulate

This version: February 2019

Abstract

We assess how disclosure affects the usability of the liquid asset buffer that banks hold due to liquidity regulation (the Liquidity Coverage Ratio, or LCR). Using recent data, we show that banks tend to disclose quite detailed information around their LCR buffer holdings, sometimes more frequent and detailed than required by regulation. This has consequences on buffer usability. Using a model, we show that such disclosures can sometimes reduce incentives for banks to use their liquid asset buffer in stress, making the buffer partially unusable.

JEL code:

Keywords:

I. Introduction

The liquidity freeze in the interbank market that followed the failure of Lehman Brothers, as well as the run on Northern Rock have prompted the introduction of new internationally harmonised regulations on bank's holdings of cash and liquid assets. Another consequence of the crisis was a renewed call for increased market transparency, in particular around banks' resilience. Indeed the runs on banks which took place during the global financial crisis were due to a lack of liquid resources compared to the short-term runnable liabilities that banks had been relying on for funding their activities. But the lack of transparency on banks' balance sheet strength was also to blame, as it left investors with little information to discriminate between healthy banks and failing banks.

In response to the regulatory gaps that the crisis had highlighted, the Basel Committee developed a new liquidity and funding regulatory framework which includes guidance to banks ensuring that they maintain two key prudential ratios at sufficient levels in normal times: the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). The Basel Committee has also implemented new disclosure requirements to improve bank transparency, a disclosure framework which it calls Pillar III of its approach to banking regulation.

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This paper assesses how the two policies interact and affect the effectiveness of the LCR. We develop a model of signalling in the context of a global game to assess how disclosure affects the usability of the LCR liquid asset buffer. Usability is central to ensuring that the LCR is effective. Indeed, the LCR's purpose is to get banks to hold a precautionary liquidity buffer that they can use to meet cash outflows in stress. This is illustrated in Charles Goodhart's metaphor of the taxi at the train station:

"*The weary traveller who arrives at the railway station late at night, and, to his delight, sees a taxi there who could take him to his distant destination. He hails the taxi, but the taxi driver replies that he cannot take him, since local bylaws require that there must always be one taxi standing ready at the station*." (Goodhart, 2008)

Ensuring that firms maintain a liquid asset buffer in normal times and keep track of it seems a significant policy improvement relative to pre-crisis supervision. Three of the most important failures during the crisis (Bear Stearns, Lehman Brothers, and Northern Rock) were indeed directly related to the mismanagement of short-term liquidity at credit institutions relying on wholesale funding. Bear Stearns' liquidity pool evaporated because it was insufficient to cover the bank's potential outflows in stress (Cox, 2008). Lehman Brothers' included in measures of its liquidity pool cash and collateral that were not under the control of the firm's treasury and could not be monetised in stress (Duffie 2010, Valukas 2010). Such assets would not qualify in a more rigorous measure like the LCR. Finally, Northern Rock would most likely have had better risk management if it had looked at the components of the LCR. A lack of liquid assets (relative to the magnitude of its reliance on short-term wholesale funding) was the main reason behind its inability to survive a dry-up in money markets (Shin, 2009).

Nonetheless, if a buffer is not usable, just like the taxi in Goodhart's analogy, it is rendered inoperable. The Basel Committee is well aware of the importance of usability to the LCR's effectiveness and made it very clear that the buffer is meant to be fully usable in stress (BCBS, 2014).

This paper relates to the literature that evaluates the effectiveness of the LCR. Some papers have assessed if the outflows and the inflows were properly defined and the weights appropriately calibrated (see Hong et al., 2014 for example). But this paper takes a different angle and focusses on the effectiveness and usability of the LCR in the context of regular regulatory and voluntary disclosure by firms.

We first show that banks tend to disclose quite detailed information around their LCR buffer holdings, sometimes richer than required by regulation. Banks follow the LCR disclosure requirements, but a large number of them give more frequent or more detail information than required. This is especially true for large banks and EU banks.

These disclosures could affect buffer usability. Banks that give more detailed information to the public may be wary of disclosing a lower LCR ratio because they fear it could trigger a negative reaction from financial markets. This is especially true for liquidity disclosures, as underlined by Praet and Herzberg (2008). This concern led the Basel Committee to only request the disclosure quarterly averages (BCBS, 2014).

In the second part of the paper, we develop a model of signalling in the context of a global game to assess how disclosure can reduce incentives to use liquid asset buffer in stress. This builds on Spence (1973) and Morris and Shin (2006). In this model, market participants can withdraw their investment if they observe a low LCR. The bank can decide to improve its LCR at a certain cost to retain a marginal number of market participants. At the equilibrium, we find that banks have the incentive to improve their LCR to retain more market participant for low or medium shocks to the LCR. But we find that for extreme shocks, banks do not make any effort to improve their LCR as it would be too costly for them. This paper has major policy implications as it provides a coherent model in which, under certain conditions, disclosures render the LCR unusable.

This paper relates to the literature on bank disclosures. There is an extensive literature on the effect of bank disclosures on bank performance and financial stability. The vast majority of the literature argues that disclosures improve transparency which reinforce market discipline. Some papers identify limitations associated with disclosure and necessary conditions for disclosure to be an effective tool to improve transparency. Nonetheless, the literature focuses on the effect of disclosure under usual funding conditions and, to the best of our knowledge, this paper is the first to assess buffer usability during a liquidity stress.

A large literature exists on the merits of transparency in banking. Interestingly it is advocated equally by the free banking literature, which seeks to eliminate bank regulation (Dowd, 1996), and more recently by the Basel Committee with the Pillar 3 of Basel III (BIS 2013, 2014), that see it as a way to incentivise banks to maintain high levels of capital and liquidity. The Basel Committee has advocated for regular and rationalised disclosure as a way to improve banks' transparency.

In both views, the benefits come from market discipline being reinforced by transparency. The underlying mechanism postulates that greater transparency, alleviates the information asymmetry between the bank and its investors (Healy and Palepu, 2001; Praet and Herzberg, 2008). It allows market participants and bank counterparties to request higher returns in case of excess risk taking and thus reduce risk taking incentives. In a theoretical model, Cordella and Levy Yeyati (1998), show that public disclosure reduces the probability of banking crises. Barth et al. (2004), examine what works for regulation and supervision with a survey of national regulatory agencies for 107 countries, primarily for 1999. The findings suggest that policies that rely on guidelines that force accurate information disclosure work to promote bank development, performance and stability. This is confirmed by Nier and Baumann (2006), who build on Barth et al. (2004) with a wider sample of 729 banks from 32 countries. They find that market discipline emerges from uninsured deposits and regulatory or voluntary disclosures.

More recent papers have focussed on the effect of liquidity disclosures. Bonner et al. (2014) conduct an empirical analysis on 7000 banks from 25 OECD countries and find that even after introducing liquidity regulation, disclosure is a major determinant of banks' liquidity choice. The higher the disclosure requirements, the higher the liquidity buffer. Studying the surprise disclosure of US banks access to the discount-window facility (DWF) in March 2011, Kleymenova (2018) finds a positive of capital markets.

Disclosure is also a mean for banks to increase transparency and distinguish themselves from riskier competitors. Regulation sets up mandatory disclosures, but banks can also conduct voluntary disclosures. Healy and Palepu (2001) find that voluntary disclosures are associated with a better

stock performance, lower bid-ask spreads and lower cost of capital. Though, they stay cautious about the quality of some of the papers that report those results.

If the literature is quite unanimous on the positive effect of transparency that comes with increased disclosure, several papers also draw the limits of disclosure. In their model, Cordella and Levy Yeyati (1998) show that when banks do not control their risk exposure, in other words, when the risk in their balance sheet is very volatile, the presence of informed depositors may increase the probability of bank failures by amplifying cyclical variability of interest rates and credit supply.

For a disclosure to be informative, especially on liquidity that has a fickle nature, Praet and Herzberg (2008) stress that it has to be comparable across banks. Voluntary disclosures that vary from one bank to another could easily be misinterpreted and destabilise the markets.

While the market discipline effect of disclosure is more analysed in a steady-state perspective, some papers suggest the limits of disclosures during a stress. Praet and Herzberg (2008) found that there was no correlation between the disclosure requirement before 2007 and banks' share price correction in 2007.

There is also a large literature on the Discount Window Facility (DWF) stigma that shows that banks prefer not to use the DWF to prevent the disclosure of their liquidity difficulties. Kleymenova (2018), examines the surprise disclosure of the DWF facility access of US banks in March 2011 and finds that after this episode banks tend to increase their liquidity holdings, which she interpret as a way for banks to avoid having to use it in the future. Armantier et al. (2015), seek to quantify this DWF stigma and find that banks were willing to pay a premium of around 44 basis points across funding sources (126 basis points after the bankruptcy of Lehman Brothers) to avoid borrowing from the DWF.

The paper rest of the paper is organised as follows. The next section describes the LCR. In the third section we turn to banks' LCR disclosure behaviour. In the fourth section we describe the model. In the fifth section we characterise equilibrium properties. The sixth section offers further discussion of implications from our analysis. The last section concludes.

II. The Liquidity Coverage Ratio

Basel III introduced two new liquidity ratios: the Liquidity Coverage Ratio and the Net Stable Funding Ratio. The LCR has a 30-days horizon while the NSFR has a one-year horizon. In this paper we focus on the LCR and its short term horizon.

The aim of the LCR is to ensure that banks hold enough market liquid assets to cover liquidity outflows over a prescribed 30 day stress. The LCR is defined as follows:

$$LCR = \frac{HQLA}{Net\ cash\ outflows\ in\ 30\ days} \geq 100\%$$

High Quality Liquid Assets (HQLA) are composed of Level 1 and Level 2 assets. Level 1 assets are considered to be highly market liquid and consist of cash, central bank reserves and debt securities issued or guaranteed by high rated governments as well as corresponding central bank and Public

Sector Entities. Level 2 assets have a lower market liquidity and have weights between 15 and 50 % that aim at reflecting the potential haircuts during a liquidity stress. Level 2 assets include certain non-financial corporate and covered bonds as well as some securitizations.

Net cash outflows capture institutions' liquidity needs over a 30-day stress period. It is the difference between assumed drawdowns of liabilities (including off-balance sheet commitments) and contractual inflows (which are capped at 75% of total outflows). Maturing unsecured interbank loans for instance are assumed to completely dry up while retail deposits are much more stable and should suffer a run of only 3 to 10 %.

Outflows (resp. inflows) are calculated by multiplying the outstanding balances of various categories or types of liabilities and off-balance sheet commitments (resp. contractual receivables) by the weights communicated in the LCR. For liabilities without fixed horizons, evidence from the 2007-2008 financial crisis has led the Basel Committee to choose much higher outflow parameters for wholesale deposits relative to retail deposits.

III. Banks' LCR disclosure behaviour

In this section we examine the LCR disclosure behaviour of a sample of banks. We first analyse the regulatory requirements for LCR disclosure for each jurisdiction. Then we manually collect data on banks' LCR disclosure and find that EU banks tend to disclose more detailed information than what required by the regulation.

1. The Sample

To investigate what banks disclose regarding their LCR, we build a sample of 45 banks from four jurisdictions: the EU, the USA, Switzerland and Japan. For the EU we distinguish between the Euro Area and the UK, which gives us five geographical regions in total.

Our sample centres on UK banks. See Table 5 in appendix for a breakdown of our sample by geographical region. We included mainly systemic banks, given that LCR disclosure requirements are limited to global and domestic systemic banks in the EU; but we also included a few non-systemic banks from the UK. We only look at information published in Q4 2017 and Q1 2018, given that all disclosure regulatory requirements for the LCR started in the end of 2017 in the EU.

We skimmed through public statement published by banks in our sample and made sure to include at least pillar 3 disclosure and annual reports for each banks.

2. Regulatory requirements

LCR regulatory disclosures have been set up by the BCBS and transposed to national regulation by each of the four jurisdiction we study. Overall, the USA, Japan and Switzerland have followed closely the BCBS recommendation. Only the EU has significantly diverged, requiring an average over the previous twelve month instead of a daily averaging for quarterly LCR quantitative information (see Table 4 in the appendix for an overview of each jurisdiction disclosure requirements). It follows that the LCR disclosure of banks in the EU is less informative than in Japan, the US, or Switzerland. This

gives more room for EU banks to engage into window dressing and convey less information on the liquidity position of the bank to investors.

The BCBS disclosure standards

The LCR disclosure standards have been published by the BCBS in January 2014 (BCBS, 2014) and integrated in the Pillar 3 disclosure requirements consolidated framework in 2017 (BCBS, 2017). It is composed of two templates: LIQA and LIQ1. In our analysis we focus mainly on the level of the LCR (included in LIQ1).

The LIQA template is a series of qualitative questions to facilitate the understanding of the results and data provided.[5] The format of Table LIQA is "flexible" to enable a bank to disclose those elements of its liquidity risk management framework that it considers relevant to its business model and liquidity risk profile. The BCBS has recommended that all banks fill and disclose this template to all banks annually.

The LIQ1 table gives quantitative information on the level of a bank's LCR (the ratio) and its components: the bank's total HQLA, its cash outflows and cash inflows. The format is fixed and banks must communicate the weighted and unweighted value of cash flows. Data must be presented as simple daily averages over the previous quarter. The BCBS has recommended to request the Template LIQ1 to all internationally active banks on a consolidated basis. The reporting must made quarterly, commencing at a bank's financial year-end 2017.

Implementation in Japan, the US, and Switzerland

These three jurisdictions have followed BCBS recommendations on the format of the table LIQ1 (for quantitative information on the LCR) and the averaging method (daily averaging). Though, the US implementation introduced a lag of one quarter and Switzerland request only an annual or semi-annual reporting of the previous quarters. The scope includes large banks from each country. For example, in the US the scope covers "all banks with $50 billion or more in total consolidated assets or $10 billion or more in total consolidated on-balance sheet foreign exposure".

EU implementation

The EU implementation has generally followed the BCBS recommendations, but has also introduced a significant change in the averaging method. Instead of requesting daily averaging of a quarter, the EU implementation requests simple averages of month-end observations over the twelve months preceding the end of each quarter. In addition, it requests a little more detail in the breakdown of the cash inflows. Only G-SIB and O-SIB must report the full liquidity disclosure requirements, other banks can report only the numerator, the denominator and the ratio.

3. Additional disclosure not required by LCR regulation

Regulatory disclosures for the LCR require banks to show amounts and ratios that are averages of several past figures (daily figures in Japan, the US, and Switzerland; monthly figures in the EU). We find that almost all banks, in the four jurisdiction we study, comply with those requirements. Even

[5] For example the information elicited includes an explanation of how stress testing is used in internal risk management, and an outline of the bank's contingency funding plans.

some small UK banks, for which it is not mandatory, tend to do it (for example West Bromwich Building society).

More importantly, some banks tend to disclose additional information that is not required by the regulatory disclosure regulation. Often, it is explicitly stated that the additional information on the LCR is a non-average and recent point in time LCR ratio disclosure. For example, we found that HSBC discloses its LCR for the 31st December 2017 in its 2017 pillar 3 disclosure, in addition to the 12 months average for Q4 2017 required by the regulation. Sometimes, it is unclear how this additional[6] LCR ratio is calculated and could be an average with a different base. For example, Barclays reports an additional LCR ratio for December 2017 in its 2017 annual report but does not explicit how it was calculated.

We find that on our sample, only banks from the EU tend to produce additional LCR disclosures, while banks from the USA, Japan and Switzerland don't. About two third of EU banks in our sample disclose additional and recent information about their LCR level. Banks from the UK seems to disclose on average even more than their peers from Euro Area: 70% of the UK banks in our sample disclose additional LCR information (Table 5 in appendix). We also find that all UK banks in the top five disclose additional information about their LCR.

We have not identify clear patterns in the choice of banks to publish additional information on their LCR. Those additional information can be found equally in pillar 3 disclosure documents, annual reports or press statement. The additional and more recent figure is not always higher compare to the regulatory required one, but it is interesting to note that it is never far below (Figure 3 in appendix). Banks with LCR close to the regulatory threshold of 100% do not seem more likely to publish more recent and non-averaged information about their LCR.

IV. Model

This section describes our model of banks' LCR disclosure. It is a model of banks' choice in a liquidity stress, where they can face a trade-off between (i) using their liquid asset buffer to meet outflows and (ii) maintaining a high LCR to conceal the stress in their LCR disclosures.

The LCR's explicit intent is that banks do (i). It is a regulatory framework that aims to guide banks' liquidity risk management and to request they hold a buffer of liquid assets in normal times, so that they can monetise them in stress. So the texts defining the LCR and implementing it in Basel Committee member jurisdictions explicitly state that the ratio is expected to fall in times of stress.

However, banks' disclosures of their LCR level can give them an incentive to avoid using the buffer. The model illustrates the role of asymmetries of information between those who manage the bank ('the bank') and those who have invested in securities issued by the bank ('market participants'). The model shows that the bank is rationally concerned about using its liquid asset buffer when disclosing buffer usage would alter market participants' beliefs regarding the bank's health and might trigger a panic among them.

[6] Additional in the sense that the regulatory required LCR ratio is already provided and differs from the second one.

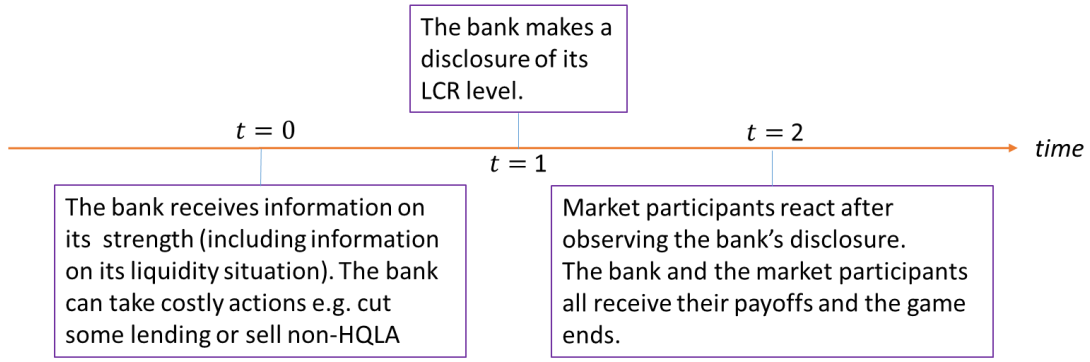
1. Timeline

The model is a three-period game. In the initial period ($t = 0$) the bank receives information on its strength. This can include news that the bank is suffering a funding stress with sudden outflows of cash, which will reduce its LCR buffer unless it acts to avoid that. Indeed, the bank can take costly actions that offer an alternative source of cash (e.g. it can cut new lending or sell assets which do not count as HQLA, the sale of which will therefore not reduce the LCR level).

In the interim period ($t = 1$), the bank discloses the LCR level resulting from both the outflows (if the bank suffered any) and the costly actions that generated cash (if the bank undertook any).

In the last period ($t = 2$), market participants – who hold securities issued by the bank – react after observing the disclosures and decide between maintaining their investment in the bank and terminating it.

Figure 1: timeline of the game



2. Payoffs and information available to players in the game

There is a continuum of risk-neutral market participants (of mass equal to 1) who have invested in securities issued by the bank. We assume that every market participant who maintains their investment in these securities get the same payoff as the bank in the last period:

$$\pi = v + l$$

where $v \in \mathbb{R}$ denotes the bank's long-term value (net present value of the bank's assets minus that of its liabilities), and $l \in [0,1]$ is the fraction of market participants who choose to maintain their investment in the securities issued by the bank. This payoff definition aims to represent agents that do not care exclusively about the long-term value of their investment but also care about its interim liquidation value.

Each market participant can terminate its investment in the bank. If doing so, they obtain a payoff of 1. This outside option is not available to the bank itself, whose payoff can only be equal to π.

Table 1: Players' payoffs

Bank	$v + l$
Market Participants	$\begin{cases} v + l & \text{if maintaining investment} \\ 1 & \text{otherwise} \end{cases}$

Public disclosure

In the interim period ($t = 1$), the bank makes a public disclosure of its LCR. The ratio results from both the outflows (if the bank has suffered any) and the costly actions it has undertaken to improve the ratio or to generate cash to meet outflows without using the buffer. We assume that this disclosure constitutes hard information, in the sense that the bank can only disclose the true state of its LCR at that point, resulting from the cash outflows it has faced and the costly actions it might have decided to undertake. Effectively, this corresponds to assuming that banks' disclosures are rigorously audited and written in a transparent language.

For simplicity, we assume that the bank only discloses the level of its ratio – not the details of its calculation (e.g. numerator, denominator). This does not constitute a strong departure from reality for the purposes of the questions we are investigating in this paper. Indeed, in a richer model where the bank would disclose subcomponents, it would still be possible and costly for the bank to adjust the inputs to these components and thus conceal the impact of stressed outflows. So there is no significant loss in the model's ability to represent the bank's incentives.

Costly actions to improve the LCR

In the initial period, the bank observes the realisation of a strength parameter $\theta \in \Theta$ that gives it information on its strength, drawn from a commonly known distribution on an open set $\Theta \subset \mathbb{R}^k$ for some integer $k \geq 1$. Specifically, we assume that the strength parameter θ gives the bank information on its long-term value and on whether it is undergoing a liquidity stress. In particular, the bank knows the cash outflows it is about to face and the LCR level $\lambda(\theta)$ that it will have afterwards, absent costly actions.

We assume that the bank can improve its LCR by an amount $e \in \mathbb{R}^+$ through costly actions. The bank can thus disclose an LCR level equal to $\lambda(\theta) + e$. But doing so reduces its long-term value by a cost $c(e)$ where $c(.)$ is a non-negative convex function of the amount e by which the bank improves its LCR. We assume that $c'(0) = 0$.

The bank's long-term value is therefore given by the following expression:

$$v = \sigma(\theta) - c(e)$$

where $\sigma(\theta)$ represents the long-term value that the bank attains if it refrains from taking costly actions to improve its LCR buffer above the level $\lambda(\theta)$.

Table 2: Players' payoff expectations

Bank	$\sigma(\theta) - c(e) + \mathrm{E}[l\|\theta, e]$
Market Participants	$\begin{cases} \mathrm{E}[\sigma(\theta) - c(e) + l\|x_i] & \text{if maintaining investment} \\ 1 & \text{otherwise} \end{cases}$

These payoffs represent the significant but imperfect alignment of incentives between the bank and market participants. The bank – which can be more realistically thought of as the insiders who

manage the bank – has a payoff equal to π, which it can directly influence by controlling the choice of e.

In contrast, market participants (as outsiders) do not control the choice of e, but they are able to walk away and obtain a reservation value of 1. Both the bank (insiders) and the market participants (outsiders) care not only about the long-term value of the bank, but also about the interim value of (or market confidence in) its securities, represented for simplicity by the fraction l of market participants who choose to maintain their investment in the securities issued by the bank, after they observe its LCR disclosure.

These payoffs are justified for instance if banks' insiders and the market participants face an interim collateral constraint or some regulatory or internal risk management requirement that lead them to wish to maintain a sufficiently high interim market value for their stake or claims on the bank. The setup of this game and the payoff structure are adapted from Morris and Shin (2006).

Convexity of the cost function

Market contacts and supervisors from several countries have expressed concerns to us about LCR buffer usability. They have pointed to actions that banks are likely to take, to avoid letting their LCR deteriorate while they experience stress outflows. These actions include cutting new lending and refraining from rolling over existing loans, so that the bank retains the inflows of cash from maturing loans instead of lending them again. Another action consists in selling assets that do not qualify as HQLA and therefore do not count as part of the LCR buffer.

Both of these actions are costly. The latter, because non-HQLA assets are generally less liquid. Illiquid assets are difficult to sell quickly at a price close to their net present value. Cutting new lending has an opportunity cost. The bank risks foregoing profitable new investments. It can also erode the bank's franchise because disappointed customers might turn to other banks to obtain or renew a loan and never return to this bank for future business.

A third type of action, pledging non-HQLA to obtain funding (from markets or from a central bank) is generally available to banks. The costs could be quite low [insert language on 'open for business']

The model assumes a convex cost: the marginal cost of improving the LCR is increasing, starting from a zero initial marginal cost (i.e. $c'(0) = 0$). This reflects the banks' ability to start with the least costly actions (and indeed face a zero initial marginal cost) and then turn to more costly ones, such as selling illiquid assets or cutting lending to projects that are profitable or important from the perspective of maintaining franchise.

Information available to market participants

We assume that each market participant observes the bank's public disclosure with some noise:

$$x_i = \lambda(\theta) + e + \varepsilon_i$$

where the market participants' noise terms $(\varepsilon_i, i \in [0,1])$ are identically and independently distributed (and also independent of θ), each according to normal distribution with mean 0 and variance $V_\varepsilon > 0$.

This information structure is motivated by the importance of strategic uncertainty and strategic complementarities in the type of situations that the model aims to describe. In reality, disclosures take a significant amount of time and effort to make sense of. Analysts of banks' disclosures are likely to use slightly different approaches to turn the disclosure documents into an assessment of the bank's health. Therefore, even if all market participants see the same document, they will each take a slightly different view of it.

Strategic uncertainty and global game

A game is said to display strategic uncertainty when players do not know with certainty what actions other players will take and what beliefs they entertain. If V_ε was allowed to be zero, then at each given level of disclosure, market participants would all take the same action since they would all have the same (precise) posterior beliefs. Because of the lack of strategic uncertainty it entails, this would generate an unrealistic discontinuity once the market participants' belief on the bank's long-term value reaches a level sufficiently high for them to choose to maintain their investment in its securities. This would also imply a discontinuity when considering the bank's best response to a market participant switching strategy (a strategy where they maintain their investment only after observing a disclosure equal to or above a cutoff value). Indeed the bank's marginal benefit of improving its LCR disclosure would in that case be equal to zero whenever the disclosure level it attains is insufficient to switch the choice of market participants from discontinuing their investment to maintaining it. The marginal benefit of improving the LCR disclosure would also be zero once the resulting disclosure level exceeds market participants' cutoff. Indeed, past that point, there is no need to improve the disclosure any further. These discontinuities are unrealistic and call equilibrium existence into question. Hence the choice of the information structure above.

Global games are a type of models that was introduced by Morris and Shin (2006). It was developed as an alternative of sunspot models with multiple equilibria where economic fundamentals was quasi unrelated to the risk of runs. In a global game, economic fundamentals are assumed to be common knowledge, but agents have a small amount of idiosyncratic uncertainty about the economic fundamentals. As a result agents are not certain of each other's behaviour in equilibrium, which suppresses the discontinuity that gives rise to multiple equilibria and instead enables a clear equilibrium prediction.

3. Equilibrium definitions

We now define players' strategies and the equilibrium concept that we use to predict players' behaviour.

Definitions

For the bank, a *strategy* is a mapping of values of the strength parameter $\theta \in \Theta$ to choices of the amount e by which the bank improves its LCR:

$$e: \theta \to e(\theta) \in \mathbb{R}^{+}.$$

For each market participant, a *strategy* is a mapping of values of their signal $x_i \in \mathbb{R}$ to a choice of either maintaining or terminating their investment in the securities issued by the bank:

$$f_i: x \to f_i(x) \in \{\text{maintain; terminate}\}.$$

Let $\hat{x} \in \mathbb{R}$. A market participant strategy f is a *switching strategy* with cutoff $\hat{x}$ if

$$x > \hat{x} \Rightarrow f_i(x) = \text{maintain, and}$$

$$x < \hat{x} \Rightarrow f_i(x) = \text{terminate}$$

We define a *symmetric equilibrium* as a pair of bank and market participant strategies $\left(\hat{e}, \hat{f}\right)$ such that all market participants have the same strategy $\hat{f}$,

$$\hat{e}(\theta) = \text{argmax}_e\{\text{E}[l|\theta, e\,] - c(e)\},$$

and for every market participant $i \in [0,1]$ and every signal value $x \in \mathbb{R}$:

$$\hat{f}(\text{x})=\text{maintain} \;\Rightarrow\; \text{E}[\sigma(\theta) - c(e) + l\,|x_i = x\,] \geq 1.$$

In other words, i maintains his or her investment only if by doing so, they expect a payoff no smaller than the (certain) payoff that they can obtain by terminating it.

A symmetric switching equilibrium is a pair of bank and market participant strategies $\left(\hat{e}, \hat{f}\right)$ which is a symmetric equilibrium and such that $\hat{f}$ is a switching strategy.

V. Main results

In this section, we characterise equilibrium behaviour. This analysis shows how asymmetries of information between the bank and market participants shape their behaviour. Indeed information asymmetries determine whether the bank relies on its LCR buffer to meet outflows when facing a liquidity stress, or if instead it takes costly actions to avoid revealing the extent of the stress it is undergoing.

We find that:

- When σ and λ are independent, then $e = 0$ in equilibrium. In other words, when learning about λ does not improve or modify market participant's beliefs about the bank's long-term value parameter σ, then it is a best response for banks to refrain from undertaking any costly actions to increase their LCR disclosure. Instead, the bank allows its LCR to drop with outflows if it suffers a liquidity stress.
- When $\Theta \subset \mathbb{R}$ and $= \lambda = \theta$, which represents an extreme positive correlation between σ and λ, the bank does undertake costly actions when facing a liquidity shock. These costly actions are maximal for intermediate values of θ. In other words, it is for liquidity shocks of intermediate strength (not the strongest) that the LCR buffer is least 'usable'

We now formally state these results in two theorems below.

Theorem 1

If λ and σ are unconditionally independent, then the bank's equilibrium strategy $\hat{e}$ is such that

$$\hat{e}(\theta) = 0, \forall \theta \in \Theta$$

Proof in appendix.

The intuition behind theorem 1 is that a bank would spare itself the cost actions aiming at increasing its LCR disclosure, if it believes that market participants will not use the LCR disclosures to update their beliefs about the bank's long-term value. There are several distinct scenarios where this would be likely to be a correct assumption – and where the result of theorem 1 would therefore hold.

Idiosyncratic shock

The first of these scenarios is one in which the bank suffers an idiosyncratic shock to its liquidity (e.g. some deposit withdrawals) and it is common knowledge that this type of liquidity shock isn't linked to or causing a deterioration in the bank's long-term value. For instance, it could be fully clear to all market participants that a liquidity shock stems from certain depositors' sudden need to withdraw larger amounts than usual, for reasons unrelated to concerns about the bank's' health.

Systemic shocks

A second type of scenarios which theorem 1 covers is one in which there is a continuum of infinitesimally small banks, all hit by a systemic shock which depletes their cash and reduces their long-term value. In this scenario, the severity of the cash outflows (common to all banks) reveals the severity of the reduction in their long-term value (also common to all banks). In this situation, if a single bank decides to improve its LCR disclosure that will not be enough to alter the beliefs of market participants regarding the common long-term value of banks. And that would in particular not alter their beliefs regarding the long-term value of that higher-LCR bank, making it a useless action for that bank.

While λ and σ are not unconditionally independent in this example, they are however independent conditional on observing the LCR disclosure of all other banks. Indeed, no bank has any chance of improving the market participants' perception of its own health, as it is commonly knowledge that all banks are equally hit by the shock.

But this reasoning – and theorem 1's result – could be overturned in a systemic shock where banks are known to be hit differentially, and where the severity of short-term cash outflows at each bank is correlated with magnitude of the reduction in its long-term value. Intuitively, in that type of scenario, each bank would have an inventive to conceal the severity with which the systemic shock has hit it. To avoid revealing the blow to its long-term value, each bank would undertake costly actions to conceal the extent of its cash outflows.

So theorem 1 delineates scenarios where a bank would fully 'use' its LCR buffer to meet stress outflows. These are scenarios in which the outflows do not inform market participants about the

bank's health. It could be either because these outflows' cause does not reveal a long-term issue or because the market already formed a precise estimate of the bank's long-term value (e.g. it if is a shock where all banks are equally hit) and therefore will not learn more from observing this bank's specific stress outflows.

Theorem 2

Assume that $\Theta \subset \mathbb{R}$ and that for every value of the strength parameter $\theta \in \Theta$, $\sigma(\theta) = \lambda(\theta) = \theta$.

Under these assumptions, there is a unique symmetric switching equilibrium. Let $\hat{e}$ denote the bank's equilibrium strategy in this equilibrium. Then for every draw of the strength parameter θ, $\hat{e}(\theta) > 0$. Furthermore, the function $\hat{e}(.)$ is continuous and unimodal.

Proof in appendix.

Theorem 2 describes the equilibrium in a situation where the bank's long-term value σ and its immediate liquidity situation λ are strongly correlated – indeed set to be equal. In this situation, the bank's equilibrium strategy is to improve the level of its LCR disclosure in all states by at least a small amount, relative to the level it would reach without taking any costly actions. This increase is strongest for intermediate values of θ.

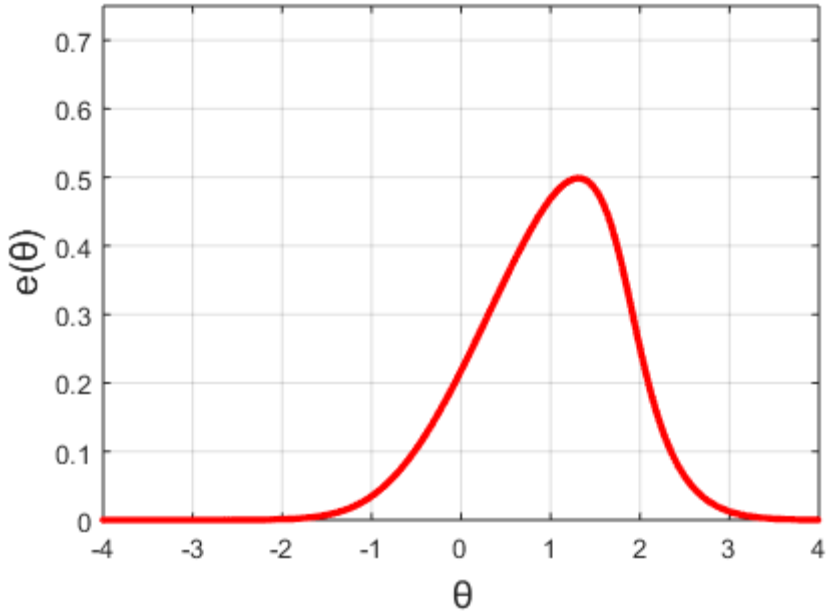
Intuitively, when the starting point λ in the bank's LCR is very low (e.g. following large outflows), it is very costly for the bank to attempt to bring its disclosure up to a level high enough that it changes the actions of a significant fraction of market participants. So the bank chooses not to try too hard to improve its LCR disclosure.

Similarly, when the starting point λ is very high, the marginal benefit to the bank of increasing its LCR disclosure is weak, since most market participants would already observe signals above their switching strategy's cutoff point and accordingly choose to maintain their investment in the banks' securities, even if the bank did not take any costly actions to boost its LCR.

In contrast, there is an intermediate range of values of the starting point λ where the marginal benefit to the bank of improving its LCR disclosure level is quite high. It is a level at which many market participants' signals are near the cutoff point, and market participants are therefore close to indifferent between maintaining their investment in the bank's securities and terminating it. The bank can thus make many of them switch actions by improving the level of its disclosure.

The optimal response of the bank for a certain cutoff (Figure 2) is a curve very close to a bell shaped but is slightly collapsed on its right side and with its peak slightly above the cutoff (cutoff at 0.82 in our example).

Figure 2: Best response to a cutoff of 0.82 (calculated using Matlab)



Calibration

This section introduces a slight generalisation in the game's payoffs, as a step towards calibrating the model. Specifically, we introduce a parameter $\alpha \in [0,1]$ reflecting the relative importance in all players' payoffs of the long-term value v and the fraction l of market participants who choose to maintain their investment. This generalises the payoff $v + l$ to $\alpha v + (1-\alpha)l$ for any value of the parameter $\alpha \in [0,1]$.

The table below gives players' payoffs in this version of the model.

Table 3: Players' generalised payoffs

Bank	$\alpha v + (1-\alpha)l$
Market Participants	$\begin{cases} \alpha v + (1-\alpha)l & \text{if maintaining investment} \\ 1 & \text{otherwise} \end{cases}$

Our future steps include establishing further properties of behaviour in equilibrium. In particular, we postulate that when α is large, $\hat{e}$ is smaller than when α is small. Indeed, if market participants give more importance to the long term value v than the short term value l, they will not react strongly to a low LCR and the bank will not make a large effort to improve the disclosed value. We also aim at calibrating α based on historical events and $c(e)$.

VI. Discussion

LCR effectiveness

The LCR's intent is to ensure that banks hold a sufficient buffer of liquid asset to meet cash outflow ni a severe 30-day idiosyncratic of market-wide stress to their funding sources and the liquidity of most of their assets. The Basel Committee (BCBS, 2013) and its member jurisdictions motivated the introduction of the LCR by highlighting that it would buy time in banking failures, making them less likely to be disorderly, and also decrease the change of failures driven by short-term liquidity concerns. Banks fail to internalise the full extent of the costs resulting from their disorderly failure in a liquidity stress, justifying a regulatory intervention. Buying time improves the efficiency of decisions made to resolve the bank or avoid some of the contagion to other banks or other parts of the financial system. Banking failures also result in credit crunches that affect end borrowers and have adverse macroeconomic consequences.

Therefore, the LCR's intent – when it can be attained – would improve welfare by mitigating the above externalities. To assess its effectiveness, and the extent by which it improves welfare, one should form a view on the following points:

i. How much additional cash and liquid asset banks hold as a result of the introduction of the LCR
ii. How likely banks are, to be using their liquid asset buffer in a liquidity stress
iii. How much this mitigates the above externalities by reducing the likelihood of liquidity stresses, or buying time and limiting their adverse impact when they do occur.

This article tackles the second item in this list. Our analysis suggest that banks disclose detailed information about their LCR – more granular than disclosure requirements warrant. This can create an incentive for banks to avoid using their liquid asset buffer in certain types of stresses. More specifically, our model shows that banks would seek to use other, more costly sources of cash in liquidity stress if that favourably influence market participants' behaviour towards the bank.

Like in Spence (1973)'s signalling model, our model's equilibrium is one in which market participants form an accurate view of the bank's health, so that the bank's costly actions do not truly conceal the extent of its difficulties. But should the bank use its LCR buffer and renounce taking these costly actions prescribed by its equilibrium strategy, market participants' beliefs regarding the bank's health would then come out much lower. The consequences would outweigh the cost to the bank or improving its LCR disclosure to avoid this.

This suggest partial success regarding item (ii) in the list above. Banks would let their LCR deteriorate in stress, but under a range of scenarios they will seek to limit this deterioration. This is not sufficient to draw a firm conclusion on the overall effectiveness of the LCR. Indeed, our analysis shows that in certain circumstances, banks would refrain from using their liquid assets for fear of disclosing a low LCR level. However, the increase in banks' liquid asset holdings attributable to the LCR's implementation might imply that its benefits (more liquid assets to use in circumstances where banks can use their buffers) exceed the costs (in terms of liquid assets that the banks would have held – absent the LCR – and would perhaps also have used more freely because it might have had disclosed anything about their level).

Microeconomics of crisis management

Our model is informative beyond the issue of LCR buffer usability. Indeed it is relevant in other crisis situations with the following features:

- The management of a firm has a choice between using a mitigant that will reveal information about the crisis, or (ii) attempting to conceal the extent of the crisis by refraining from sing this mitigant – or even taking alternative actions – at some cost for the firm's long-term value
- Market participants are less precisely information that the firm's management. They might therefore over-react to disclosures of news that the bank has attempted to mitigate a critical situation that they were not previously aware of.

One example of such a situation, predating the LCR, is the liquidity stress on Bear Stearns in March 2008. Bear Stearns' senior management explicitly considered whether it was best to (i) be seen to mitigate the nascent run on the firm by making vocal interventions to reassure markets, or (ii) avoid giving any impression that the firm had to modify its ordinary course of action. Observers said the latter view prevailed (Vanity Fair, 2008).

VII. Conclusion

This article shows that banks tend to disclose quite detailed information around their LCR buffer holdings, sometimes richer than required by regulation. And this has consequences on buffer usability. Banks that give more detailed information to the market may be vary to disclose a lower LCR ratio to avoid to send a bad signal and trigger a negative reaction from the market. This article develops a model of signalling in the context of a global game to assess how disclosure can reduce incentives to use liquid asset buffer in stress. In this model, market participant can withdraw their investment if they observe a bad LCR. Bank can decide to improve its LCR at a certain cost. At the equilibrium, we find that banks have the incentive to improve their LCR to retain more market participant for low or medium shocks. But we find that for extreme shocks, banks do not make any effort to improve their LCR as it would be too costly for them. We parametrise the model to quantify the obstacle to usability. This paper has major policy implications as it provides a coherent model in which, under certain conditions, disclosures render the LCR unusable. Future steps include refining the calibration of the model to provide a better estimation of which kind of shock renders the LCR unusable.

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Appendix

Table 4: summary of LCR disclosure regulatory requirement

	Data required	Scope	frequency	Averaging method
BCBS	• LIQ1 • LIQA	At least all internationally active banks	• quarterly	Simple average of daily LCR of the past quarter
EBA	EBA tables LIQ1 (quantitative info) and LIQA (qualitative info)	• G-SIB and O-SIB must provide detailed disclosures • Non-G-SIB and non-O-SIB can report only the ratio and the numerator and denominator	• EBA table -> All quarters, at least annually • EBA qualitative information -> at least annual	simple averages of month-end observations over the twelve months preceding the end of each quarter
US	BCBS table	• all banks with $50 billion or more in total consolidated assets or $10 billion or more in total consolidated on-balance sheet foreign exposure • covered nonbank financial companies that are required to calculate an LCR	• Quarterly disclosure with several weeks lag	Simple average of daily LCR of the precedent quarter
Japan	• LIQ1	Compliant with BCBS		
Switzerland	• LIQ1	• SIFIs • Banks with simplified reports must only report the ratio, the numerator and the denominator	• Semi-annual or annual reporting of all previous quarters	• Simple daily averages for SIFIs • Monthly simple averages for banks with a lighter reporting requirements

Table 5: Sample and voluntary disclosure

	Disclosed a recent non-averaged figure	Total
UK	70%	23
EA	64%	11
USA	0	6
Japan	0	3
Switzerland	0	2

Figure 3: LCR disclosure, regulatory and voluntary, for Q4 2017

Appendix: micro foundations for information structure

Micro-foundation for the following information structure used in the model:

$$x_i = \lambda(\theta) + e + \varepsilon_i$$

Banks can take costly actions to improve the overall message of its disclosures, of which perhaps the ratio is a key part, but not the only one. Therefore, if it wishes to conceal a stress, the bank would seek to improve not only the ratio, but also some of the components, and perhaps even additional information disclosed in a document.

Disclosures take a significant amount of time and expertise to make sense of for market participants and Healy and Palepu (2001) find that there are indeed systematic biases in financial analysts' outputs, potentially arising from the conflicting incentives that they face. We assume that each market participant has analysts who use slightly different models. Thus, they end up observing slightly different estimates of $\lambda(\theta) + e$ (which is the most informed estimate one could get to, without having direct knowledge of θ and e). Alternatively, the idiosyncratic noise ε_i could also represent idiosyncratic and independent cognitive biases that analysts can't realise they add to their estimates.

Appendix: proofs of theorems 1 and 2[7]

Proof of theorem 1

Let f denote the strategy of a market participant. We say f is a *constant strategy* if either $f(x) = \text{ maintain}, \forall x$, or $f(x) = \text{ terminate}, \forall x$.

Lemma 1
If the strategy of market participants is constant, then the bank's best response is $e \equiv 0$.

Proof of lemma 1
Let $\theta \in \Theta$ denote a value of the bank's health parameter such that $e(\theta) > 0$.
Let $\mu(x)$ denote the mass of market participants that choose maintain after the bank discloses a level x.
By assumption,
$\mu\big(\theta + e(\theta)\big) = \mu(\theta)$.
Therefore,
$\sigma(\theta) - c\big(e(\theta)\big) + \mu\big(\lambda(\theta) + e(\theta)\big) < \sigma(\theta) - c(0) + \mu\big(\lambda(\theta)\big)$
But this contradicts the optimality of $e(\theta)$. □

Consider an equilibrium $\big(\hat{e}, \hat{f}\big)$. Assume $\hat{f}$ is not constant.

Let $\mu(x) = \mathrm{P}\left(Z^x \in \hat{f}^{-1}(\{\text{maintain}\})\right)$, where Z^x is a random variable distributed normally, with mean x and variance V_ε.

[7] We are still working on these proofs. Some parts are only sketched in this draft.

This implies that $\mu(x) = \int_{-\infty}^{+\infty} G(z)\varphi\left(\frac{z-x}{\sigma_\varepsilon}\right)\frac{1}{\sigma_\varepsilon}dz$, where $G(z)$ denotes the set function for the subset $\hat{f}^{-1}(\{\text{maintain}\}) \subset \mathbb{R}$.

Let $g_\lambda(y) \coloneqq \mu(y) - c(y-\lambda)$.

Let $A_\lambda \coloneqq \text{argmax}_y\{g_\lambda(y)\}$

Because of the convexity of $c(.)$, $A_{\lambda(\theta)}$ is almost everywhere a singleton.

Therefore, there exists a function $\delta: \mathbb{R} \to \mathbb{R}$ such that $\hat{e}(\theta) = \delta(\lambda(\theta))$ almost everywhere. Indeed, δ can be constructed by setting $\delta(\lambda(\theta)) = A_{\lambda(\theta)}$ for all the values for which $A_{\lambda(\theta)}$ is a singleton.

Therefore, the posterior belief of market participants regarding $\sigma(\theta)$ conditional on observing $\lambda(\theta) + \hat{e}(\theta)$ cannot differ from their prior. Hence the market participants' strategy is constant.

By lemma 1, this implies that $e \equiv 0$. □

Proof of theorem 2

We are still working on this proof and some of its parts are only sketched in this draft.

First, note that $e(\theta) > 0$ for all θ, because market participants' strategy is a switching strategy, and therefore there is always a non-zero return to increasing e, while $c'(0) = 0$.

Let $\mu(x)$ denote the mass of market participants that choose 'maintain' after the bank discloses x.
Let $\hat{\gamma}(\theta) \coloneqq \mu(\theta + \hat{e}(\theta))$.

Lemma 2
$\theta - c\big(\hat{e}(\theta)\big) + \hat{\gamma}(\theta)$ is increasing in θ.

Proof of lemma 2
Consider $\theta, \tilde{\theta} \in \Theta$ such that $\theta < \tilde{\theta}$.
And assume that

$$\tilde{\theta} - c\left(\hat{e}\big(\tilde{\theta}\big)\right) + \hat{\gamma}\big(\tilde{\theta}\big) \leq \theta - c\big(\hat{e}(\theta)\big) + \hat{\gamma}(\theta)$$

This would imply the following:

$$\tilde{\theta} - c\left(\hat{e}\big(\tilde{\theta}\big)\right) + \hat{\gamma}\big(\tilde{\theta}\big) < \tilde{\theta} - c\big(\hat{e}(\theta)\big) + \mu(\tilde{\theta} + \hat{e}(\theta))$$

But this contradicts the equilibrium requirement that $\hat{e}(\theta)$ achieves the $\max_e\big\{\tilde{\theta} - c(e) + \mu(\tilde{\theta} + e)\big\}$. □

Lemma 3
$\theta + \hat{e}(\theta)$ is increasing in θ.

Proof of lemma 3
Consider $\theta, \tilde{\theta} \in \Theta$ such that $\theta < \tilde{\theta}$.
And assume that

$$\tilde{\theta} + \hat{e}\big(\tilde{\theta}\big) \leq \theta + \hat{e}(\theta)$$

Because of the bank's choice at θ,

$$-c\big(\hat{e}(\theta)\big) + \mu\big(\theta + \hat{e}(\theta)\big) \geq -c\left(\tilde{\theta} - \theta + \hat{e}\big(\tilde{\theta}\big)\right) + \mu(\tilde{\theta} + \hat{e}\big(\tilde{\theta}\big))$$

By convexity of $c(.)$, this implies that:

$$c\left(\hat{e}(\theta) - \left(\tilde{\theta} - \theta\right)\right) - c\left(\hat{e}\left(\tilde{\theta}\right)\right) \leq \mu\left(\theta + \hat{e}(\theta)\right) - \mu(\tilde{\theta} + \hat{e}\left(\tilde{\theta}\right))$$

Rearranging:

$$-c\left(\hat{e}\left(\tilde{\theta}\right)\right) + \mu\left(\tilde{\theta} + \hat{e}\left(\tilde{\theta}\right)\right) \geq -c\left(\hat{e}(\theta) - \left(\tilde{\theta} - \theta\right)\right) + \mu\left(\theta + \hat{e}(\theta)\right)$$

This contradicts the optimality of the bank's choice at $\tilde{\theta}$. □

Note that the posterior of market participants regarding the distribution of θ is increasing, in the sense of first order stochastic dominance, with respect to x_i.

So $\mathrm{E}\left[\theta - c\left(\hat{e}(\theta)\right) + \hat{\gamma}(\theta)|x_i\right]$ is increasing in x_i and crosses 1 only once, from below. This verifies the existence of a symmetric switching equilibrium.

It is easy to establish the properties of the bank's best response to a market participant switching strategy as the function can be derived analytically.