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# THE IMPACT OF LIQUIDITY REGULATION ON BANK INTERMEDIATION

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# ABSTRACT

## The Impact of Liquidity Regulation on Bank Intermediation*

We analyze the impact of non-compliance with a requirement similar to the Basel III Liquidity Coverage Ratio and its impact on bank intermediation applying Regression Discontinuity Designs. Using a unique dataset on Dutch banks, we show that non-compliance with a liquidity requirement causes banks to pay and charge higher interest rates as well as to increase borrowing and decrease lending on the long-term interbank market. Apart from lending rates, the short-term market is unlikely to be affected by the requirement. While non-compliance with a liquidity requirement does not seem to directly affect corporate lending rates, we find evidence that institutions with a liquidity deficiency turn to the long-term interbank rate as reference for lending to non-financial institutions.

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## 1. Introduction

Prior to the financial crisis in 2008, asset markets were liquid and funding was easily available at low cost. However, the emergence of the crisis showed how rapidly market conditions can change, causing several institutions - despite appropriate capital levels - to experience severe liquidity issues, to the point where only an intervention by the competent authority could prevent a shutdown of the institution.

In response to this crisis, the Basel Committee on Banking Supervision (BCBS) has drafted a new regulatory framework with the aim to achieve a more robust banking system.[1] Besides new rules for capital and leverage, the framework also specifies a short-term and a long-term liquidity requirement as key concepts to reinforce the resilience of banks against liquidity risks. The Liquidity Coverage Ratio (LCR) is a short-term ratio that requires financial institutions to hold high quality liquid assets at least equal to their net cash outflows over a 30-day stress scenario.[2]

According to Bech and Keister (2013), the new reform is likely to impact monetary policy implementation. In many jurisdictions, the central bank relies on the overnight rate at which financial institutions lend central bank reserves to one another as operating targets for monetary policy implementation. A bank with a liquidity deficiency has stronger incentives to obtain long-term interbank funding and is more likely to borrow from the central bank's standing facility. Both of these actions help a bank to fulfill its reserve requirement and thus lower the need to access overnight markets. This lower demand for overnight loans may drive down the corresponding interest rate, whereas the increased demand for long-term funding is likely to steepen the short end of the yield curve. In such a situation, central banks may be required to adjust their monetary policy frameworks and use the long-term interbank rate as additional target for monetary policy implementation.

Apart from these relative changes between short-term and long-term loans, a li-

[1] See BCBS (2010) and BCBS (2013).

[2] Please note that throughout the paper we refer to short-term loans in case of maturities shorter than 30 days while long-term loans are defined as loans with maturities longer than 30 days.

quidity requirement may also directly impact an institution's P&L.[3] A bank facing quantitative liquidity regulation is required to increase its liquidity buffer by either buying more liquid or longer-term assets, which come at high costs, presumably increasing an institution's marginal costs of funds. As institutions will try to pass on these increased costs to their clients, higher lending rates and lower lending volumes might be a consequence.[4]

Price increases in the interbank money market are likely to translate into price increases of other interest rates in the economy, including corporate lending rates. On top of that, institutions facing a liquidity requirement might turn to the long-term instead of the short-term interbank market as reference for corporate lending, causing a second indirect effect on lending rates to corporates.

Against this background, we empirically analyze the impact of the LCR on banks' role as financial intermediaries. Specifically, we assess the impact of a quantitative liquidity requirement on volumes and interest rates in the unsecured interbank money market and the implications of these changes for both monetary policy implementation and private sector lending. Our analysis is based on unique data on the Dutch quantitative liquidity requirement 8028 (henceforth DLCR)[5] in combination with data on banks' lending and borrowing behavior in the Dutch unsecured interbank money market and banks' lending to non-financial institutions.

Our analysis suggests that the DLCR causes banks to both pay and charge higher interest rates for long-term interbank loans. With respect to volumes, our results show that banks with a regulatory liquidity deficiency borrow more and lend less in the form of long-term loans. With short-term lending rates increasing as well, we also find evidence for a binding liquidity requirement leading to increased marginal costs of funds. Apart from lending rates, however, short-term loans seem to be unaffected by liquidity regulation. Our analysis also shows some signs that banks, when facing a liquidity requirement, turn to the long-term interbank rate as reference for corporate lending.

[3] P&L refers to an institution's Profit and Loss Statement. Its broad purpose is to show the ability of an institution to generate profit.

[4] See Blundell-Wignall and Atkinson (2010).

[5] See DNB (2003).

While our paper provides novel insights into banks' role as financial intermediaries in the presence of liquidity regulation, some caveats are due. Firstly, we obtain our data from regulatory reports, which might be subject to a measurement bias. Regarding our sample, the major issues connected to this bias are caused by additional Pillar 2 liquidity requirements and corrections to the DLCR ratio. As the additional Pillar 2 requirements can be added to the Pillar 1 requirement, the former issue is relatively easy to address. The latter issue is caused by regulators detecting deficiencies in banks' reporting. Correcting these deficiencies causes some banks to actually become non-compliant although it is only reflected in the DLCR of the subsequent month. Since banks can be expected to react to the correction immediately, we assume that detected non-compliance equals reported non-compliance.[6] A second shortcoming is that we observe some clustering above the threshold. While neither a sufficient nor a necessary condition, the absence of clustering makes the validity of Regression Discontinuity Designs (RDD) more likely. Given the custom among Dutch banks to hold precautionary liquidity buffers, however, a clustering seems natural while not violating the more important assumption of banks being unable to precisely control their DLCR.

A key takeaway from our analysis is that as long as only a small of share of banks are non-compliant, neither monetary policy implementation nor private sector lending are likely to be affected by the LCR. However, once a considerable share of banks falls below the threshold, the aggregate reaction of banks is likely to change interest rates, presumably affecting central banks as well as non-financial corporates. In case of an aggregate shortage, the short end of the yield curve is likely to steepen, increasing interest rates for corporates and requiring central banks to use the long-term interbank rate as additional target rate for monetary policy implementation. At the least, both central banks and corporates are therefore advised to closely monitor the LCR of the banking system.

[6]Please note that with the aim to address potential issues connected to incorrect reporting, we conducted an extensive outlier analysis.

## 2. A primer on the DLCR

Similar to the LCR, the DLCR is based on classic liquidity "coverage" considerations, used by banks and some regulators. Banks are required to hold an amount of liquid assets at least equal to their net cash outflows over a 30-day stress period:[7]

$$DLCR = (Actual\ Liquidity) - (Required\ Liquidity\ within\ 30\ days) \geq 0 \quad (1)$$

Actual Liquidity (*AL*) is defined as the stock of liquid assets minus haircuts plus recognized cash inflows weighted by degree of liquidity. Required Liquidity (*RL*) comprises of assumed calls on contingent liquidity lines, assumed withdrawals of deposits as well as assumed drying up of wholesale and derivative funding. Apart from cash, government bonds as well as highly rated covered bonds, the DLCR additionally allows banks to include most central bank eligible securitizations as part of their liquidity buffer while the LCR allows structured products only to a limited extent. With respect to deposits and contrary to the LCR, the DLCR does not distinguish between "stable" and "less stable" retail deposits which have different runoff rates under stress and are classified according to a set of predefined conditions. Importantly however, maturing unsecured interbank loans have the same treatment (100% runoff assumption) under both regimes. Suppose that a non-compliant bank obtains an overnight loan in the unsecured interbank money market:

$$DLCR = (AL + Overnight\ Loan) - (RL + 100\% * Overnight\ Loan) \geq 0 \quad (2)$$

As can be seen from equation 2, interbank loans with maturities shorter than 30 days do not help banks to eliminate a DLCR deficiency. The reason for this is that any loan with a corresponding maturity shorter than 30 days comes due within the DLCR horizon and therefore not only increases a bank's *AL* but also its *RL*.
By contrast, interbank loans with maturities longer than 30 days can help a bank to reach its regulatory threshold, as the repayment occurs outside the 30 day horizon. In equation 2, this means that only *AL* increases while *RL* remains unchanged. In

[7] Please note that for the purpose of this analysis, we calculate ratios of Actual over Required Liquidity.

light of this special feature, Bech and Keister (2013) argue that the introduction of such a liquidity requirement makes interbank loans with maturities longer than 30 days relatively more valuable.

On an aggregate level, the differences between the DLCR and the LCR are insignificant. Given that the LCR is stricter with regard to the definition of liquid assets, while the DLCR applies considerably higher outflow rates and haircuts, the differences between the two regimes cancel each other out.[8] In 94% of the cases, banks are jointly (non-)compliant with the LCR and the DLCR while the correlation coefficient of the two ratios is almost 87%.[9]

### *2.1. A liquidity requirement and lending*

There are two channels via which a liquidity requirement can have an impact on lending. The first one is straightforward and directly caused by an institution's non-compliance. If an institution falls below its liquidity requirement, its marginal costs of funds increase, incentivizing the institution to raise interest rates and cut lending. The second channel is indirect and reflected by banks shifting their interbank activity towards the longer-term market, which is likely to increase the importance of the longer-term rate as reference point for private sector lending. Subsequently, this is likely to increase an institution's lending rates.

The rationale behind this goes back to the seminal paper of Ho and Saunders (1981), arguing that banks' role as financial intermediaries exposes them to a reinvestment risk.[10] As pointed out by Maudos and de Guevara (2004), demand for loans and supply of deposits reach the bank at different points in time which forces them to temporarily turn to the interbank money market in case of excessive demand for loans or insufficient supply of deposits.[11] In order to compensate for the risk of refinancing interest rate increases in the money market, institutions set their

[8]This is especially true since the new compromise, described in BCBS (2013).

[9]The entire spectrum of banks reporting the DLCR includes only a few banks with large differences between the LCR and DLCR. These banks are niche banks without access to money markets and are therefore not included in our analysis.

[10]Please be also referred to Lerner (1981), Pong Wong (1997) or Saunders and Schumacher (2000).

[11]In the end, the interplay between corporate lending and interbank markets is similar to the one between interbank markets and central bank reserves. As one functions as a backup for the other, developments in the backup market affects the pricing in the other market.

interest rates to corporates as margin relative to money market interest rates.
Apart from a more general pass-through of increased costs of funds in case of non-compliance, a quantitative liquidity requirement is likely to increase the point of reference for corporate lending. As institutions facing a liquidity requirement have a particular incentive to borrow more long-term loans, it is very likely that these institutions set their private sector lending relative to the long-term instead of the short-term rate. Given the generally higher prices for long-term loans plus the additional markup caused by higher demand, a liquidity requirement is likely to drive up private sector interest rates.

### *2.2. A Liquidity Requirement and Monetary Policy Implementation*

Many countries have adopted frameworks using overnight interest rates as operating targets for monetary policy implementation. As laid out by Bech and Keister (2013), most central banks offer deposit and lending facilities that allow banks to deposit or borrow reserves. Theoretically, these two facilities constitute the upper and lower bound for the interbank market rate. Central banks aim to adjust reserves in such a way that interbank lending takes place at a target rate lying within these boundaries.

In the canonical model of monetary policy implementation, banks hold reserves primarily to satisfy their average reserve requirements.[12] When deciding on their borrowing and lending volumes in the interbank money market, banks have to balance two concerns: If they borrow too little and experience a large payment outflow, banks have to draw on the central bank's lending facility which comes at a higher cost than borrowing in the market. However, borrowing too much is also inefficient as it means the bank holds reserves that could have been lent out in the market at a rate higher than the central bank deposit rate.

With the (D)LCR in place, banks need to fulfil a second requirement. When deciding on their borrowing and lending volumes in the interbank money market, banks have to take into account the risk of falling below the (D)LCR threshold.

Banks not complying with their liquidity requirement will take into account the possibility of being forced to borrow from the central bank in order to remedy a

[12] See Poole (1968).

(D)LCR deficiency. As argued by Bech and Keister (2013), in this case a considerable term premium arises: loans with maturities longer than 30 days become relatively more valuable. Bech and Keister (2013) further argue that overnight interest rates will fall, given that longer-term loans perform a double duty: as well as counting towards the (D)LCR, they also help to fulfill the average reserve requirement. It therefore becomes increasingly likely that banks will end up holding higher reserves, which presumably reduces the marginal value of overnight funding.

In this situation, the central bank cannot follow the standard procedure for monetary policy implementation. That is, using the overnight interest rate as operating target. In a situation with term premiums on loans with maturities longer than 30 days and lower overnight interest rates, Bech and Keister (2013) argue that there is no amount of reserve supply that will yield an overnight rate equaling the target rate. In such a situation, central banks may need to adjust their frameworks for monetary policy implementation.

## 3. Data

### *3.1. The Dutch Interbank Market*

The interbank market works as an over-the-counter (OTC) market so prices and volumes are not publicly known.[13] Financial institutions settle various types of payments in TARGET 2 (the interbank payment system of cross-border transfers within the EU), such as payments on behalf of customers, bank-to-bank payments, payment of the cash leg of a security trade, and pay-ins for the CLS system (continuous linked settlement) to settle foreign exchange transactions. In 2010, the Dutch part of TARGET 2 had 61 direct participants including a few large British banks, a daily average of 34.000 transactions and a daily turnover of 295 billion euro. The Dutch part of TARGET 2 constitutes roughly 13% (10%) of the complete TARGET system in terms of volume (transactions).

In a recent working paper Heijmans et al. (2010) analyze the Dutch interbank market, based on four periods: 1) January 2004 to June 2007: financial markets

[13] Please note that eMID is an exception to this rule.

were smooth and well-functioning; 2) July 2007 to August 2008: first turmoils; 3) September 2008 to June 2009: failure of Lehman Brothers, followed by a severe period of stress, and 4) July 2009 until December 2011: Unconventional monetary policy measures by the ECB. Although we include a period-specific dummy in all our regressions, it is important to understand the different periods in the Dutch unsecured interbank money market.

[Insert Figure 1 here]

Comparing the average interest rates paid in the Dutch interbank market with EONIA (see Figure 1a), it becomes evident that before the failure of Lehman Brothers, Dutch interest rates are highly correlated with the Euro-area average. After the collapse of Lehman Brothers, however, the interest rates in the Dutch interbank market have increased less sharply than EONIA, suggesting that the effect of Lehman Brothers' failure is somewhat smaller for Dutch banks compared to other European banks. According to Heijmans et al. (2010), the average total turnover fell by roughly 25% after the failure of Lehman Brothers.
It can be seen that although the credit crunch after the failure of Lehman Brothers led to higher interest rates and lower volumes, the Dutch interbank market remained sufficiently active and diversified for the purpose of our analysis.

### *3.2. Data Sources*

In order to analyze the effects of a quantitative liquidity requirement on banks' behavior, we bring together data on 1) DNB's monthly prudential liquidity reporting; 2) bilateral transactions in the interbank market for different maturities (volumes and prices); 3) new loan issuances and the respective interest rates of Dutch banks to the private sector; 4) the Eurosystem's Bank Lending Survey, and 5) risk indicators and other measures calculated from the balance sheet.
For the DLCR, we use data for 54 Dutch banks from January 2004 to December 2011 from DNB's regulatory liquidity reporting. For the purpose of this analysis, we calculate a ratio of *AL* over *RL*. To understand the determinants of banks' non-compliance with a liquidity requirement, we calculate a dummy which is 1 in case an institution's DLCR is above 100% and 0 otherwise.

With respect to the unsecured interbank money market, we use the same raw data as Heijmans et al. (2010). In a recent working paper, Heijmans et al. (2010) describe how loans can be identified and thus volumes and prices extracted, from the observable flows between banks. The authors build on the seminal paper by Furfine (1999) and improve the algorithm to include durations of up to one year.[14] As well as being applied in the US using Fedwire (Demiralp et al. (2006), Ashcraft and Bleakley (2006), Hendry and Kamhi (2009)), the algorithm has also been applied in Norway (Akram and Christophersen (2010)), and Germany (Braeuning and Fecht (2012)). The algorithm returns information on the borrowing and lending institution, paid interest rates, total value as well as maturity of the loan.

The data on lending comes from DNB's socio-economic reporting and is collected for the monetary statistics of the Eurosystem. The data covers the period from January 2004 to December 2011 and carries information on 26 Dutch banks. The dataset distinguishes granted loans, larger and smaller than 1 million as well as with maturities shorter and longer than 1 year and contains information on new issuances (flows) and not stocks and the respective interest rates. Total lending in this regard does not include lending which occurred due to the draw down of committed credit lines, overdrafts or open debit or credit card deficits.

The Eurosystem's Bank Lending Survey includes 8 Dutch banks, covering roughly 65% of the Dutch sector's total lending. We use monthly data from 2004 to 2011.[15] The BLS is addressed to senior loan officers and its main purpose is to enhance the understanding of bank lending behavior in the euro area. The BLS contains information on how the banks' credit standards as applied to the approval of loans or credit lines to enterprises have changed over the past three months or expectations of changes over the next three months and what factors contribute to these changes. The possible answers regarding the development of lending standards range from 1 ("tightened considerably") to 5 ("eased considerably"). The BLS also includes banks' perception of demand for loans by enterprises.

[14] For a more detailed description of the functioning of the algorithm, see Heijmans et al. (2010).

[15] Please note that the BLS is only reported quarterly. Given, however, that banks are required to report their experience of the last 3 months as well as a forecast for the following 3 months, an extrapolation of the data to a monthly frequency should not cause any problems.

As additional control variables we include a large number of bank-specific controls, such as institutions' capital holdings or profits. For all balance sheet measures we use monthly data per bank from January 2004 to December 2011 from DNB's prudential reporting.

## 4. Methodology - Regression Discontinuity Design (RDD)

In order to analyze the impact of a liquidity requirement on banks' behavior in the interbank money market, we apply Regression Discontinuity Designs (RDD). The application of RDD goes back to the classic work of Thistlethwaite and Campbell (1960) as a way of estimating treatment effects in a nonexperimental setting where treatment is determined by whether an observed *assignment variable* exceeds a known cutoff point. In our dataset, the continuous DLCR ratio is the assignment variable while the threshold of 100% defines the cutoff below which an institution receives treatment.

In a RDD setting, the assignment to treatment and control groups is not random but rather caused by imprecise control over a known assignment variable. While other comparable approaches, such as IV estimations, require exogenous assignment, in RDD randomized variation is a consequence of agents' inability to precisely control the variable near the known cutoff.[16]

As stated by Hahn et al. (2001), the main advantage of RDD is that it requires less strict assumptions regarding the assignment of treatment compared to other non-experimental approaches. Ensuring the presence of this random component, however, is essential for the internal validity of RDD.

### *4.1. Establishing the internal validity of applying RDD*

According to Lee and Lemieux (2010), the key condition for RDD to be valid is that individuals are not able to *precisely* manipulate the assignment variable. This follows Lee and Lemieux (2010), who state that when individuals have imprecise control over the assignment variable, even if some are especially likely to have values near the cutoff, every individual will have approximately the same probability

[16] See Lee (2008).

of having a value that is just above or just below the cutoff. The reason why RDD allows for more relaxed assumptions is that, in contrast to other comparable setups, we directly observe the assignment variable which in turn is mainly determined by a set of of predetermined and observable characteristics of the individual.

For RDD to be valid for our sample, banks should not be able to precisely choose whether they will be compliant or not but rather have imprecise control over non-compliance. Intuitively, some banks will be more likely to be compliant than others, which implies that banks have some influence on their DLCR. At the same time, it is sensible to assume that unexpected actions of other market participants make it impossible for a bank to precisely determine their liquidity ratio.[17] Banks' control over their DLCR is similar to the example provided by van der Klaauw (2002) regarding students' capability to manipulate their high school grades and SAT scores. As argued by the authors, even if students have perfect knowledge about the threshold determining the assignment of scholarships, it seems implausible that students can perfectly control their grades.

Although the assumption of imprecise control is intuitively plausible for our sample and we cannot directly test it, Lee and Lemieux (2010) point towards the discontinuity of the assignment variable's aggregate distribution as potential test for imprecise control. As McCrary (2008) argues, if the density of the assignment variable is continuous for each individual, then the marginal density over the population should be continuous as well. However, as pointed out by the authors, the density test is only appropriate to confirm the validity of RDD while it is neither necessary nor sufficient for identification.

Being a requirement all banks have to fulfill, the DLCR naturally shows a clear discontinuity in aggregate density with considerably less observations below the threshold. The large increase in density above the threshold is caused by all banks holding precautionary, additional liquidity buffers. Although being unable to precisely control their DLCR, banks can hold very large additional liquidity buffers, making it unlikely to be hit by a liquidity shock, large enough to cause non-

[17] Such actions can for instance be drawdowns of committed credit and liquidity facilities, interest rate changes and the subsequent movements in assets' market values, large deposit withdrawals, exchange rate movements, changes in central bank policies, defaults of important counterparts and even simple measurement or interpretation errors.

compliance. Naturally, this leads to an increased density above the threshold. At the same time, however, holding large liquidity buffers comes with high opportunity costs.[18] These opportunity costs are likely to have a double effect: they set a natural limit to the size of the additional buffers and they are likely to enforce banks' usual incentives to hold liquid assets. Using similar data, De Haan and Van den End (2013) for instance find that smaller Dutch banks, foreign subsidiaries and less capitalized banks are more likely to hold precautionary liquidity buffers. The reason why less capitalized banks hold larger precautionary buffers is that these banks have less precise control over their DLCR. The net effect of these two mechanisms results in the same likelihood to be close to the cutoff.[19] This implies that although some banks might be particularly likely to have values near the cutoff, every bank will have approximately the same probability of having a value below the cutoff. To rephrase, if a bank falls below the threshold, it underestimated its liquidity risk which can happen to banks with low or high liquidity risks.[20]

As argued by Lee and Lemieux (2010), an alternative approach for testing the validity of the RDD is to analyze whether the baseline covariates are balanced on both sides of the cutoff. An intuitive way of doing this is to conduct both a graphical as well as a formal estimation analysis to show that other predetermined bank-specific characteristics are smooth around the cutoff. Figure 2 shows histograms of several bank-specific and macroeconomic control variables on the y-axis and averages of banks' DLCRs within the same 1% bucket. To ensure that our covariates are truly predetermined, we use the lags of all bank-specific variables.

[Insert Figure 2 here]

Observing Figure 2, a few patterns become evident. To begin with, lower liquidity holdings seem to be associated with higher volatilities of the covariates. This fact, however, is not caused by economic factors but rather by the lower number of ob-

[18] See for instance Baltensperger (1980) as well as Santomero (1984).

[19] Please note that the rationale for holding additional buffers above the liquidity requirement are the same as the ones for holding liquid assets in the first place.

[20] To illustrate this point, the Appendix includes a modified version of the test-taking RDD example, described in Lee and Lemieux (2010).

servations. At the same time, this pattern suggests that banks below the threshold are sufficiently heterogeneous to exclude the possibility that only certain types of banks are below the threshold.

Another general observation is that most controls are somewhat correlated with the DLCR while there does not seem to be a discontinuity around the threshold. Banks' capital holdings, for instance, seem to be negatively correlated with banks' DLCR while we cannot observe a "jump" around the 100% cutoff. At the same time, it can be seen that the pattern is not homogenous, meaning that there is a considerable number of banks with low capital and liquidity holdings and vice versa. A similar, though somewhat weaker, effect can be observed for banks' size and the ECB interest rate as well as the GDP growth rate. Profitability, on the other hand, does not show a recognizable pattern while it does show the earlier discussed high volatility below the threshold. With respect to banks' cds spreads, we can see weak evidence for higher spreads being associated with higher liquidity holdings.

While the graphical analysis confirms the smoothness assumption of the covariates around the cutoff, we complement this analysis with formal regressions. Following Lee and Lemieux (2010), we run Seemingly Unrelated Regressions (SUR) with each equation representing a different covariate.[21] SUR allows us to test whether the coefficients for compliance are jointly insignificant for all bank-specific characteristics. Table 1 shows our results with respect to the impact of non-compliance on a set of lagged bank-specific variables.

[Insert Table 1 here]

As can be seen in Table 1, *Compliant* does not have a statistically significant impact on the lagged bank-specific variables. These results allow us to conclude that our equations are correctly specified and therefore provide further evidence that RDD is valid in our sample, yielding unbiased estimates of the impact of non-compliance with a liquidity requirement on banks' role as financial intermediaries.

[21] See Lee and Lemieux (2010) for further details.

## 5. Analysis

After showing the validity of RDD, in this section we present and discuss our analysis, which is divided into a graphical and a formal estimation part.

### *5.1. Graphic Analysis*

Figure 3 shows the relationship between institutions' DLCR ratios and their corresponding short-term and long-term interbank borrowing rates (Figures 3a and 3b) as well as volumes (Figures 3c and 3d).

[Insert Figure 3 here]

Looking at Figures 3a and 3b, we can see that banks' interbank borrowing rates seem to show some evidence of discontinuity, suggesting that banks with DLCRs below 100% pay higher interest rates when borrowing in the interbank money market. While we can observe more variance as well as outliers below the threshold, most borrowing rates seem to be higher for banks below 100%. However, there does not seem to be a difference between short-term and long-term rates.
With respect to short-term borrowing volumes, there seems to be a clear discontinuity. Interestingly however, this discontinuity is not at the threshold but somewhat lower at 98%. For long-term borrowing volumes, our graphical analysis does not point to the presence of a clear discontinuity.
Figure 4 is similar to Figure 3 but shows banks' interbank lending instead of borrowing. Figures 4a and 4b show the relationship between institutions' DLCR ratios and their corresponding short-term and long-term interbank lending rates while Figures 4c and 4d refer to lending volumes.

[Insert Figure 4 here]

Figures 4a and 4b look very similar to the ones for the borrowing rates suggesting that institutions' borrowing and lending rates are highly correlated. Again, we can see some discontinuity around the threshold of 100%, suggesting that institutions below the cutoff charge higher interest rates when lending in the interbank markets. Again, we can observe outliers without clear differences between the patterns for short-term and long-term rates. With respect to lending volumes (Figures 4c and 4d), we can see a clear discontinuity at the threshold. Without exceptions, the average long-term lending volume of banks below the threshold is lower than long-term lending of banks with DLCRs above 100%.

Summarizing, we can observe a discontinuity at the threshold for interbank borrowing and lending. This discontinuity seems to be clearer for interest rates than for volumes. With the exception of long-term lending volumes, however, this discontinuity is not clear cut and needs to be confirmed with econometric analyses.

### *5.2. Estimation*

The RDD literature typically distinguishes parametric and non-parametric analyses. As pointed out by Roberts and Whited (2012), when deciding between the two approaches one faces the usual trade-off between precision and bias. Starting with Hahn et al. (2001), nonparametric approaches are more common in the literature. A likely reason for this practice is the increased risk of misspecification connected to parametric analyses. As pointed out by Lee and Lemieux (2010), although misspecification is a general problem in any other setting, it is particularly severe in RDD. As specification errors are minimized globally, linear regression models can - despite the presence of misspecification - be interpreted as linear predictors. RDD, on the other hand, depends on small *local* specification around the cutoff and therefore does not gain from global minimization. Following Hahn et al. (2001) as well as McCrary and Royer (2011), we estimate all models using both approaches while focussing on non-parametric estimations.

Apart from choosing the functional form, it is important to choose the optimal bandwidth. While there are several different approaches used in the literature, none of these approaches provides a clear answer and the selection of bandwidth remains a subjective judgement call.[22] As pointed out by Roberts and Whited (2012), it is best to choose a bandwidth and experiment with a variety of other bandwidths to illustrate the robustness of results. Following our earlier argumentation, we consider an upper limit an appropriate measure for our sample. Given this and that our

[22] See for instance McCrary and Royer (2011) who use a rule-of-thumb bandwidth or Ludwig and Miller (2007) applying cross-validation techniques.

sample is naturally limited at 0%, a rectangular kernel between 0% to 200% seems intuitively plausible which we therefore use as baseline scenario. The regression takes the following form:

$$Y_{i,t} = \beta_0 + \beta_1 D_{i,t} + \beta_2 (DLCR - 100)_{i,t} + \beta_3 (D * DLCR)_{i,t} + \beta_4 Mat_{i,t} + \beta_5 Controls_{i,t(-1)} + \varepsilon_{i,t} \quad (3)$$

where $Y_{i,t}$ describes eight distinct dependent variables. The pattern of the classifications is straightforward: We define four variables relating to an institution's borrowing in the interbank market. Two of these variables refer to prices while the remaining two refer to volumes. Prices are defined as the spread between an institution's volume and maturity-weighted average of the monthly borrowing rate in the unsecured interbank money market with the respective ECB rate while volumes refer to the natural logarithm of an institution's total borrowing. Given the different treatment between loans with maturities longer and shorter than 30 days, we further classified the dependent variables referring to prices and volumes into these two categories. We follow the same pattern with respect to institutions' lending.

The right hand side is in line with Roberts and Whited (2012) as well as Lee and Lemieux (2010), reflecting common practice when estimating an RDD model with a pooled nonparametric approach. It includes the dummy variable $D_{i,t}$ which allows us to gain insight into whether a bank with a DLCR deficiency behaves differently. The variable is 1 in case a bank's liquidity ratio is between 100% and 200% and 0 otherwise (between 0% and 100%).

To avoid the results to be driven by an institution's liquidity holdings rather than its compliance with the requirement, we include the variable $(DLCR - 100)_{i,t}$, reflecting the distance of a bank's DLCR from the cutoff. As argued by Roberts and Whited (2012), subtracting the cutoff value from the assignment variable, ensures that the intercepts reflect the value of the regression functions at the cutoff. To allow our regression function to differ on both sides of the cutoff, we additionally include the interaction term $(D * DLCR)_{i,t}$.

In a valid RDD, the main argument for still including covariates is to reduce the sampling variety. Especially when experimenting with different bandwidths and polynomials, the inclusion of covariates can be helpful. However, as in Lee (2008), the inclusion of covariates often helps to validate the RDD as opposed to improving the efficiency of the estimates. $Mat_{i,t}$ reflects the average maturity of an institution's monthly borrowing and lending respectively while $Controls_{i,t(-1)}$ includes a large number of lagged bank-specific control variables as the current GDP growth rate.[23] More specifically, we include an institution's lagged capital, size, cds spread, rating, profitability, return on equity, a variable reflecting the relationships of an institution in the interbank money market as well as a variable describing the average solvency of an institution's counterparts.[24] All regressions include bank-clustered robust standard errors.

### *5.3. Results*

#### *5.3.1. Borrowing in the Interbank Market*

Table 2 shows that non-compliance with the quantitative liquidity requirement causes banks to pay significantly higher interest rates for unsecured interbank loans with maturities longer than 30 days while interest rates for loans with shorter maturities are unaffected. The table also shows that non-compliant banks increase their borrowing volumes of loans with maturities longer than 30 days.

Table 2 includes four distinct dependent variables. Column 1 shows our results with the dependent variable being the spread between the volume and maturity weighted average borrowing rate and the ECB lending rate, only taking into account loans with maturities shorter than 30 days. Column 2 shows the results with a similar dependent variable, with the difference being that only loans with maturities longer than 30 days are taken into account. In column 3, the left-hand side variable is represented by the natural logarithm of an institution's maturity weighted total borrowing, taking into account only loans with maturities less than 30 days. Similar to columns 1 and 2, column 4 differs from column 3 in that it includes only loans with maturities longer than 30 days.

[Insert Table 2 here]

[23] Please note that $Controls_{i,t(-1)}$ corresponds largely with the variables in Table 1.

[24] See Cocco et al. (2009).

Column 1 shows that *Compliant* banks do not pay less than their peers for unsecured interbank loans with maturities shorter than 30 days. For loans with maturities longer than 30 days (column 2) on the other hand, non-compliant banks pay 10 basis points (bp) more. Since non-compliant banks pay only more for loans which count towards their DLCR, these results are a first indication that non-compliance with a quantitative liquidity requirement increases the demand for long-term loans. Given the setup of our estimation, we conclude banks that do not comply with their quantitative liquidity requirement pay 10 bp more *by choice* as this helps them to meet their quantitative liquidity requirement. Expressed in standard deviations, non-compliance causes banks to pay almost 0.25 more than their peers. Given its mean of 108 bp, an increase of the long-term borrowing rate by 10 bp is economically significant.

Apart from non-compliance with the liquidity requirement, also banks' general liquidity holdings ($DLCR - 100\%$) play a role. This effect, however, is very small. A DLCR increase of 1 percentage points (pp) results in a reduction of long-term interest rates by 1 bp.

With respect to our additional control variables, we find only very small differences between the different maturity buckets (columns 1 and 2). Banks with better *Relationships* pay lower interest rates while loans with longer *Average maturities* are relatively more expensive. An institution's *Capital* only reduces short-term borrowing rates while it does not affect loans with maturities longer than 30 days. However, as a 1 pp increase of *Capital* implies a decrease of the short-term borrowing rate by only 1 bp, the impact of capital seems economically insignificant.

Columns 3 and 4 show that non-compliance with the liquidity requirement causes banks to borrow more loans with maturities longer than 30 days, while this does not apply to shorter maturities. The rationale behind this result is straightforward and similar to that applying to interest rates. In the absence of a binding liquidity requirement, the reason why banks borrow money in the short-term unsecured interbank market (i.e. to meet their average reserve requirement and to cover unexpected outflows) is the same for all banks. With a liquidity requirement in place, loans with longer maturities are relatively more in demand among non-compliant banks, given that these loans count towards meeting their regulatory requirement. Non-compliance increases a bank's borrowing of long-term loans by 25%.

An institution's *Relationships* have a positive impact on its borrowing while its *Capital* reduces long-term borrowing volumes. An increase of 1 pp reduces borrowing volumes by 4%.
Summarizing, our results suggest that a liquidity requirement affects banks' borrowing behavior on the long-term interbank market. Non-compliant banks pay significantly higher interest rates and borrow larger volumes of unsecured interbank loans with maturities longer than 30 days while liquidity regulation is not found to have any effect on short-term loans.

#### *5.3.2. Lending in the Interbank Market*

Table 3 shows that a quantitative liquidity requirement increases interest rates for interbank lending with maturities shorter and longer than 30 days. With respect to volumes, on the other hand, non-compliance with the regulatory liquidity requirement causes banks to only reduce their granting of loans with maturities longer than 30 days, while shorter loans are unaffected.

[Insert Table 3 here]

Table 3 follows a similar pattern as Table 2. It includes four different variables: column 1 refers to the spread between the volume and maturity weighted average lending rates for loans with maturities shorter than 30 days and the ECB interest rate, while column 2 takes account only of maturities longer than 30 days. Columns 3 and 4 also differ in terms of maturities while both having the natural logarithm of an institution's maturity weighted total lending as dependent variables.
Columns 1 and 2 show that non-compliant banks do not only charge higher interest rates for loans with maturities longer than 30 days but also for those loans with shorter maturities. Our results therefore suggest that apart from increasing the relative value of long-term loans, non-compliance with the liquidity requirement causes banks to increase short-term interest rates. A likely reason for this second effect is that non-compliance increases banks' marginal costs of funds, which can be at least partially passed on to clients. Given their means of 86 bp and 110 bp, increases of 9 bp (short-term rates) and 12 bp (long-term rates) can be considered to be economically significant.

Table 3 also shows that banks with high levels of *Capital* charge lower interest rates. Our results suggest that an increase in the capital ratio by 1 pp reduces lending rates by 1 bp and 2 bp respectively. Our other control variables show the expected signs with *Relationships* reducing and the *Average maturity* increasing lending rates.

Columns 3 and 4 show our results when the natural logarithm of a bank's maturity weighted lending volumes is included as dependent variable. Again, we distinguish between maturities shorter (column 3) and longer (column 4) than 30 days. Our results with respect to lending volumes suggest that non-compliance with the liquidity requirement causes banks to issue 27% less loans with maturities longer than 30 days, while loan issuances for shorter maturities are unaffected.

Our results with respect to solvency suggest that a 1 pp increase in an institution's *Capital* ratio reduces lending volumes between 3% and almost 10%. While this result initially seems counterintuitive, it is not uncommon in the literature. De Haas and Van Lelyveld (2010) and De Haas and Van Lelyveld (2013), for instance, find that higher capitalized banks grant less credit, which the authors attribute to these banks being more conservative and to their therefore higher holdings of capital. This is in line with the results of Black and Strahan (2002) who find undercapitalized banks to be prone to moral hazard, leading them to rapidly expand (higher-risk) lending.[25] Our results with respect to *Relationships* indicate that an increase of an institution's relationships by 1 standard deviation increases its lending volumes for longer maturities by 18%.

Summarizing, our results suggest that a quantitative liquidity requirement causes banks' demand for long-term loans as well as their marginal costs of funds to increase. Specifically, non-compliance causes banks to charge higher lending rates in general and to reduce lending volumes for loans with maturities longer than 30 days.

[25] See also Degryse et al. (2012) who find that better capitalized banks reduce regional banking fragility.

## 6. A shift to longer maturities and the private sector

While non-compliance with the liquidity requirement has a straightforward direct effect on lending rates, it might also incentivize institutions to use the long-term rate as reference for corporate lending:

$$L_{i,t} = \beta_0 + \beta_1 (D * IB\,Rate)_{i,t} + \beta_2 D_{i,t} + \beta_3 IB\,Rate_{i,t} + \beta_4 Controls_{i,t} + \varepsilon_{i,t} \tag{4}$$

where $L_{i,t}$ refers to the spread between an institution's corporate lending rate and the ECB interest rate.

The key explanatory variable is $(D * IB\ Rate)_{i,t}$, describing the interaction term between the dummy of an institution's non-compliance with the DLCR and the spread of its borrowing rate in the interbank money market with the ECB interest rate.[26] The interaction of non-compliance with either the short-term or the long-term interbank market rate allows us to gain insight in whether the long-term interbank market rate is relatively more important for non-compliant banks.

Along with the interaction term, we also include the dummy as well as the interbank market rate as separate terms. Our additional $Controls_{i,t}$ are motivated by the literature on corporate lending which typically considers banks' funding costs, expected losses on lending activities and the extent of equity funding as key determinants of corporate lending.[27] As proxies for the expected default risk on an institution's lending activities, we include an institution's lending standards measured by its response to the BLS. We also include the lag of an institution's total equity as percentage of total assets, a bank's perception of credit demand as well as a large number of macroeconomic and other institution-specific and loan-specific factors. Depending on the used approach, all regressions include either bank-fixed effects or robust bank-clustered standard errors.[28]

Table 4 shows evidence that the role of the long-term interbank rate as reference

[26] Please note that for the purpose of this analysis we changed the dummy from being 1 in case of compliance to 1 in case of non-compliance.

[27] See Brown et al. (2010), Fabbro and Hack (2011) or Deans and Stewart (2012).

[28] Please note that equation 4 does not allow us to conclude causality. Rather, a potential outcome can be that the corporate lending rates of non-compliant banks are more associated with their long-term interbank rate than the one of their compliant peers.

for corporate lending seems to be more important for non-compliant banks.
Table 4 is divided into two sections. While the dependent variable (banks' interest margin over the ECB interest rates when lending to corporates) is the same in all specifications, $IB\ rate$ refers either to an institution's long-term (columns 1 to 3) or short-term borrowing rate in the interbank market (columns 4 to 6). For both sections, Table 4 shows pooled OLS as well as random and fixed effects estimations.

[Insert Table 4 here]

Columns 1 to 3 show that banks' long-term borrowing costs in the interbank money market are positively associated with the spread of the corporate lending rate with the ECB interest rate. While non-compliance itself does not seem to have a direct impact on banks' interest margins, the role of the long-term interbank borrowing rate is particularly large for non-compliant banks, captured by the variable $(Non-Compliant * IB\ Rate)$. An increase of the borrowing rate by 100 bp is associated with an increase of the corporate lending rate between 5 bp and 6 bp for all banks and a considerably larger increase between 34 bp and 54 bp for banks with a liquidity deficiency.
A similar pattern can be observed for short-term interbank rates. Importantly, however, the difference between non-compliant and compliant banks is significantly smaller with respect to short-term interbank rates. While an increase of the borrowing rate by 100 bp leads to an increase of banks' interest margins between 7 bp and 8 bp for all banks, non-compliant banks increase their corporate lending rates between 29 bp and 46 bp.
These results suggest that while the short-term interbank rate is a more important reference for all banks, corporate lending rates set by non-compliant banks seem to be specifically responsive to movements of the long-term interbank rate.
Regarding our additional control variables, we can see that banks' $Lending\ standards$ do not significantly affect interest rates while $Lagged\ capital$ and $Credit\ demand$ have a large impact on corporate lending rates. An increase of an institution's $Lagged\ capital$ by 1 pp increases its interest margins between 65 bp and 115 bp. As stated before, a likely explanation for this somewhat surprising result is that banks with higher holdings of capital are more conservative and therefore charge

higher interest rates.[29]

## 7. Sensitivity Analysis

In order to check the robustness of our results, we conducted a number of sensitivity tests. Given the high importance of choosing the correct functional form as well as bandwidth in an RDD, our sensitivity analyses mainly aim at confirming the chosen RDD approach. Having said this, we run a number of additional checks.

### *7.1. RDD specific robustness checks*

Our RDD specific robustness checks include either changes of the 1) polynomial form; 2) the bandwidth, or 3) whether covariates are included or not. Our results are very sensitive to changes in the polynomial function.[30] While most coefficients turn insignificant, the few which remain statistically significant have implausibly high coefficients as well as standard errors, clearly pointing towards misspecification. While this was already suggested by our graphical analysis, the sensitivity tests clearly confirm the linear functional form as best fit for our sample. The results of all variables are relatively robust to changing the bandwidth and to an in- or exclusion of covariates. As can be seen in Tables 6 to 9, with the exception of the very smallest bandwidth (99-101), the treatment effect is significant within different bandwidths and not overly sensitive to the inclusion of covariates. Interestingly, however, the standard deviations as well as the coefficients of our regressions are larger for smaller bandwidths. A likely explanation for this is the low number of non-compliant banks in our sample. It is likely that our sample does not include sufficient observations for conducting thorough analyses with smaller bandwidths.

Generally speaking, our results are relatively robust and we can observe treatment effects for several different specifications. Due to the small number of observations below the cutoff, however, our analysis neither allows for the inclusion of higher order polynomials, nor do we find any significant effect for very small bandwidths.

[29] See De Haas and Van Lelyveld (2010) and De Haas and Van Lelyveld (2013).

[30] Note that our dataset does not allow the inclusion of a 3rd order polynomial. Including a term of this order causes our dummy, reflecting compliance with the liquidity requirement, to be dropped.

### *7.2. Other checks*

To exclude the possibility of liquidity regulation having a particular effect on overnight interest rates, we additionally include a dummy which is 1 in case of overnight loans and 0 otherwise. The dummy is insignificant in all specifications which is intuitively straightforward, given that the calculation of our dependent variables controls for a loan's maturity. The split between large and small banks does not result in any major differences. Our results are also robust to adding more macroeconomic variables, namely inflation and other ECB interest rates.

## 8. Interpretation and Conclusion

The aim of this study is to show the impact of a quantitative liquidity requirement on banks' role as financial intermediaries. Specifically, we analyze whether non-compliance with the Dutch quantitative liquidity requirement changes banksŠ behavior in the unsecured interbank money market and whether these changes have an impact on private sector lending and monetary policy implementation.
Our analysis suggests that a quantitative liquidity requirement increases the demand for long-term loans, making them relatively more expensive. While increased demand for long-term loans could decrease the relative value of short-term funding, we do not find evidence confirming this theory. Rather, we observe an increase of short-term lending rates and no effect on short-term borrowing rates. The increase of short-term lending rates is likely to be caused by the institution's increased marginal costs of funds due to it being non-compliant and its intention to at least partially pass on these costs to clients. The insignificance of the liquidity requirement on short-term borrowing rates might be attributable to the fact that our sample only shows non-compliance of individual institutions without the presence of an aggregate shortage. Although non-compliance with the requirement might reduce the relative value of overnight funding, reduced demand of only a number of institutions is unlikely to actually drive down overnight rates. While a liquidity requirement does not seem to have a direct impact on corporate lending rates, our analysis confirms the straightforward correlation between interbank rates and the interest rate margin on private sector lending. On top of that, we find some evidence that banks with a liquidity deficiency turn to the long-term interbank rate as

reference for corporate lending.

The impact of the LCR depends crucially on the extent of non-compliance as it determines the interplay between the relative value reduction of overnight funding and banks ability to pass on their increased funding costs to clients. With clarifying that banks are expected to actually use their liquidity buffers during stress, the BCBS made the occurrence of aggregate shortages less likely and in a way more predictable. Central banks, on the other hand, are advised to closely monitor banks' compliance and take into account the interaction with the LCR when conducting monetary policy operations. Whether or not further measures are needed (such as the recognition of committed central bank facilities in the LCR), crucially depends on the economic and legal context in which they take their effect. Answering this question, however, is beyond the scope of this paper.

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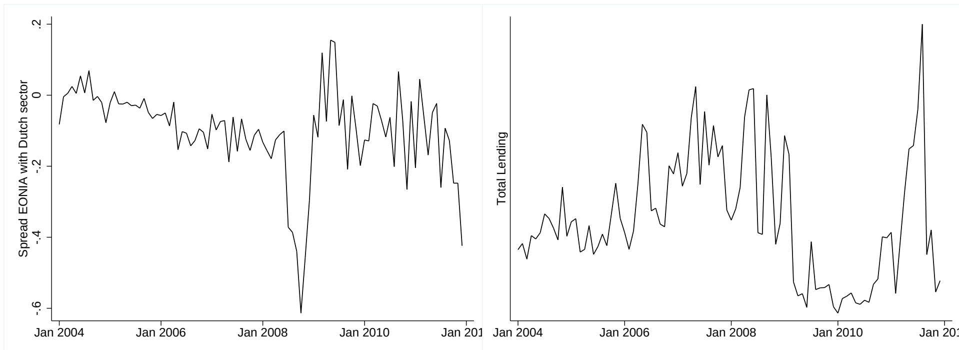
## Appendix

Figure 1: Dutch Interbank Market over time




a: Interest Rates

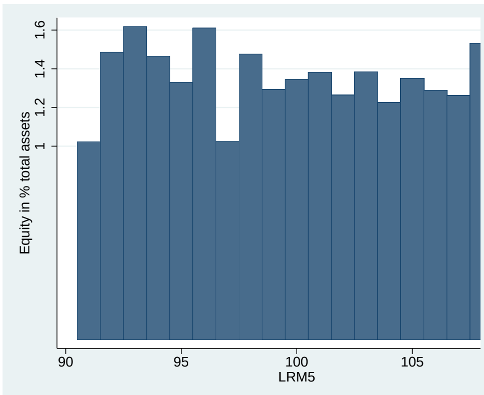
b: Total Lending

**Table 1** – Seemingly Unrelated Regressions of the covariates

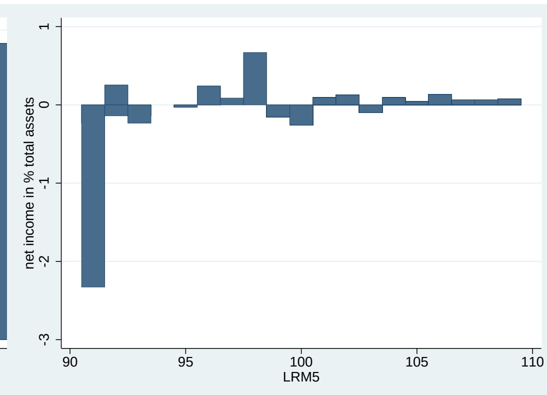
| VARIABLES (lags) | Capital | Size | CDS | Rating | Profit | RoE |
|---|---|---|---|---|---|---|
| Compliant | -0.02 | 0.37 | -20.30 | 0.19 | -0.00 | -0.00 |
| | (0.10) | (0.56) | (115.53) | (1.11) | (0.00) | (0.02) |
| DLCR | 0.05*** | -0.27*** | 44.81*** | 0.43*** | -0.00*** | -0.00*** |
| | (0.01) | (0.04) | (8.21) | (0.08) | (0.00) | (0.00) |
| Constant | 1.19*** | 19.80*** | 66.20*** | 3.63*** | 0.00*** | 0.02*** |
| | (0.02) | (0.11) | (21.85) | (0.21) | (0.00) | (0.00) |
| Observations | 381 | 381 | 381 | 381 | 381 | 381 |
| $R^2$ | 0.121 | 0.114 | 0.073 | 0.074 | 0.032 | 0.025 |

*Note: The table shows Seemingly Unrelated Regressions with the dependent variables being lagged Capital (equity as percentage of total assets), Size (natural logarithm of total assets), CDS (cds spreads), Rating, Profit (income as percentage of total assets) and RoE (return on equity). Compliant is a dummy which is 1 in case an institution complies with its liquidity requirement and 0 otherwise. DLCR is an institution's continuous liquidity holdings. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while robust standard errors are in parentheses.*

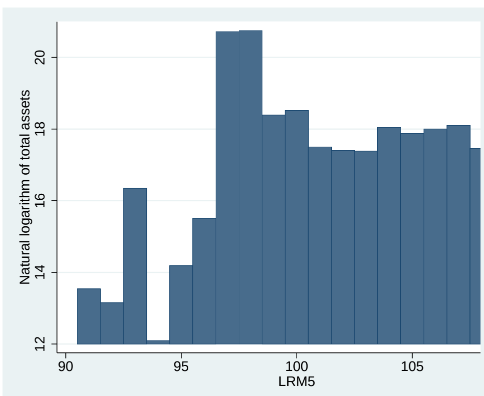
Figure 2: Smoothness of lagged control variables



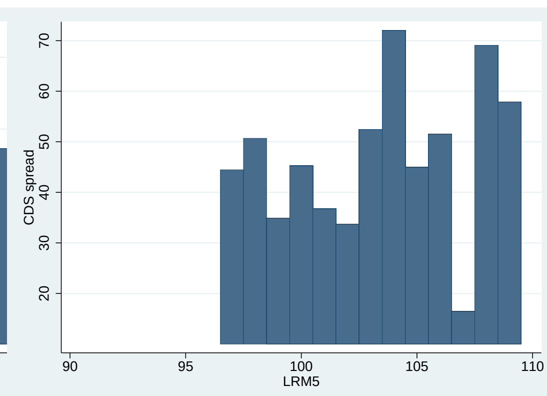

a: Lagged Capital



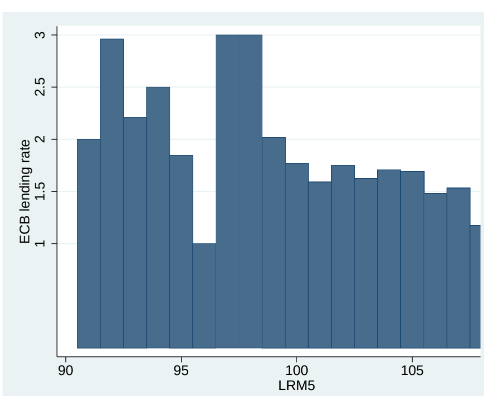

b: Lagged Profitability



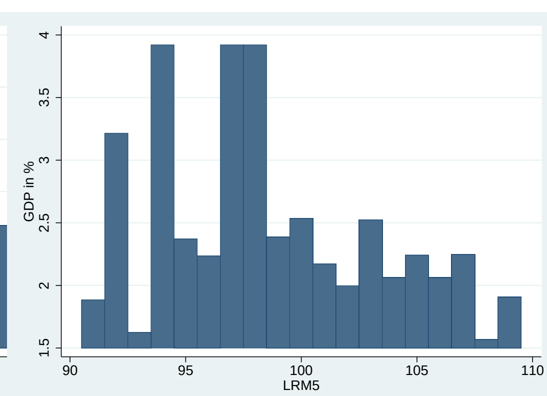

c: Lagged Size




d: Lagged CDS spreads

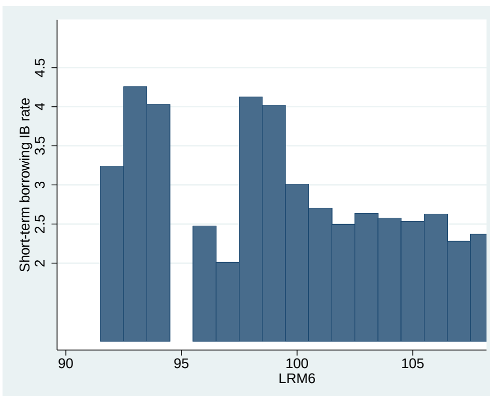



e: ECB interest rate

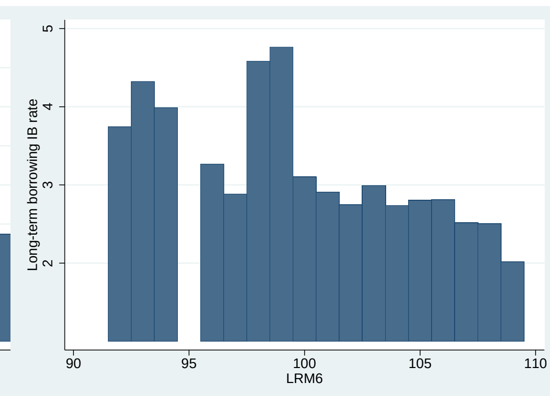



f: GDP growth rate

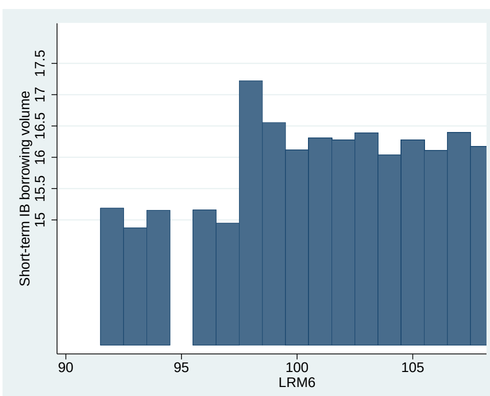
Figure 3: Interbank Borrowing



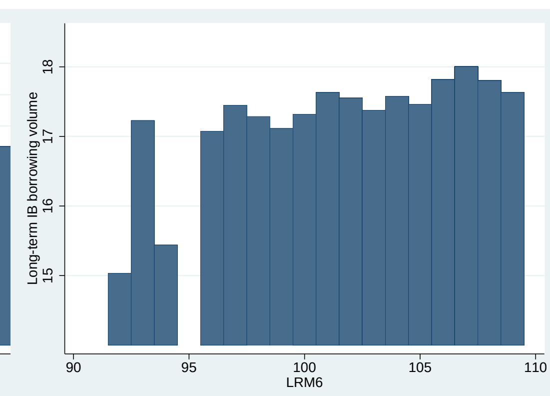

a: Short-term rate




b: Long-term rate

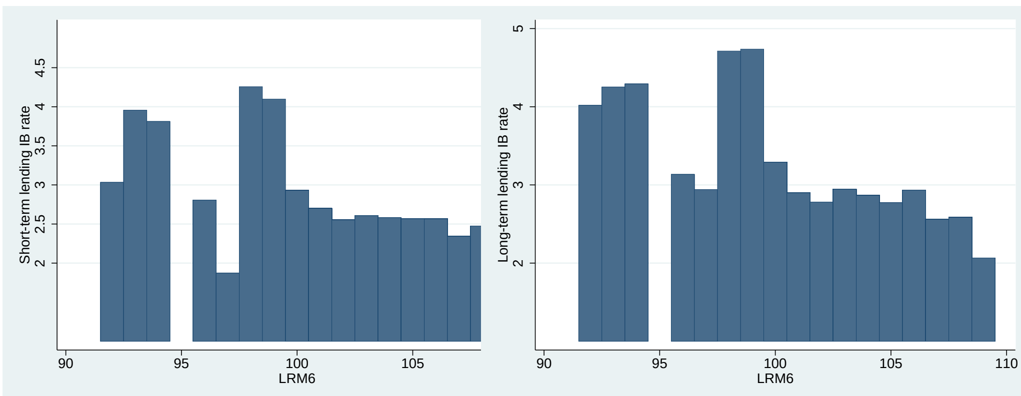



c: Short-term volume



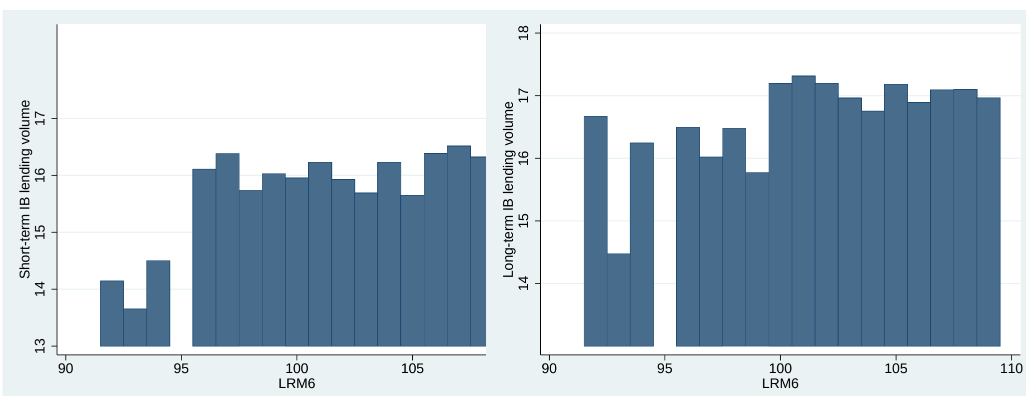

d: Long-term volume

Figure 4: Interbank Lending




a: Short-term rate

b: Long-term rate




c: Short-term volume

d: Long-term volume

**Table 2** – Interbank Borrowing

| | Interest Rates | | Volumes | |
|---|---|---|---|---|
| VARIABLES | SHORT | LONG | SHORT | LONG |
| Compliant | -0.08 | -0.10** | 0.27 | -0.30*** |
| | (0.48) | (0.05) | (0.17) | ((0.08)) |
| DLCR-100% | 0.00 | -0.01* | 0.02 | -0.04* |
| | (0.01) | (0.01) | (0.02) | (0.02) |
| Compliant*DLCR | -0.00 | 0.01 | -0.03 | 0.04* |
| | (0.01) | (0.01) | (0.02) | (0.02) |
| Lagged capital | -0.01** | 0.00 | -0.02 | -0.04* |
| | (0.01) | (0.01) | (0.02) | (0.02) |
| Lagged relationships | -0.13*** | -0.18*** | 1.55*** | 1.02*** |
| | (0.04) | (0.04) | (0.15) | (0.17) |
| Average maturity | 0.00*** | 0.01*** | -0.00 | -0.01 |
| | (0.00) | (0.00) | (0.00) | (0.01) |
| Period Dummy | Yes | Yes | Yes | Yes |
| Constant | 0.80*** | 0.68*** | 16.93*** | 16.20*** |
| | (0.13) | (0.13) | (0.51) | (0.54) |
| Observations | 962 | 1012 | 888 | 888 |
| $R^2$ | 0.51 | 0.48 | 0.13 | 0.12 |

*Note: The table presents results of Regression Discontinuity Designs (RDD) following a pooled nonparametric approach. The dependent variable is either the spread between the monthly volume-weighted average borrowing rate and the respective ECB interest rate (Columns 1 and 2) or the natural logarithm of monthly maturity weighted total borrowing (Columns 3 and 4). To specifically account for the DLCR's 30-day horizon, columns 1 and 3 refer only to maturities shorter than 30 days while columns 2 and 4 take only into account maturities longer than 30 days. The purpose of the above regressions is to show whether banks which do not comply with their quantitative liquidity requirement non-Compliant behave differently in the unsecured interbank money market. As required by RDD, we include the distance of an institution's DLCR to the 100% threshold ($DLCR - 100\%$) as well as an interaction term ($Compliant * DLCR$). Additionally, we include Lagged Capital, an institution's LaggedRelationships, Average maturity of the issued loans and a large number of additional lagged bank-specific variables (capital, size, cds spread, rating, profitability and return on equity) as well as period dummies and GDP growth. To avoid our results to be driven by large outliers, we drop the lowest 1% as well as the highest 99% of all variables. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses.*

**Table 3** – Interbank Lending

| | Interest Rates | | Volumes | |
|---|---|---|---|---|
| VARIABLES | SHORT | LONG | SHORT | LONG |
| Compliant | -0.09** | -0.12* | 0.14 | 0.31** |
| | (0.04) | (0.05) | (0.30) | (0.17) |
| DLCR-100% | -0.01* | -0.01 | 0.02 | 0.06** |
| | (0.01) | (0.01) | (0.04) | (0.03) |
| Compliant*DLCR | 0.01* | 0.01 | -0.02 | -0.06** |
| | (0.01) | (0.01) | (0.05) | (0.03) |
| Lagged capital | -0.01** | -0.02*** | -0.10*** | -0.03* |
| | (0.00) | (0.01) | (0.02) | (0.02) |
| Relationships | -0.19*** | -0.23*** | 1.46*** | 1.26*** |
| | (0.04) | (0.05) | (0.25) | (0.18) |
| Average maturity | 0.01*** | 0.00*** | 0.05*** | -0.01** |
| | (0.00) | (0.00) | (0.01) | (0.00) |
| Counterparty solvency | 0.00 | 0.01 | 0.02 | 0.07** |
| | (0.01) | (0.01) | (0.05) | (0.03) |
| Period Dummy | Yes | Yes | Yes | Yes |
| Constant | 0.67*** | 0.77*** | 15.39*** | 16.87*** |
| | (0.10) | (0.13) | (0.59) | (0.44) |
| Observations | 1301 | 1002 | 994 | 994 |
| $R^2$ | 0.52 | 0.51 | 0.12 | 0.13 |

*Note: The table presents results of Regression Discontinuity Designs (RDD) following a pooled nonparametric approach. The dependent variable is either the spread between the monthly volume-weighted average lending rate and the respective ECB interest rate (Columns 1 and 2) or the natural logarithm of monthly maturity weighted total lending (Columns 3 and 4). To specifically account for the DLCR's 30-day horizon, columns 1 and 3 refer only to maturities shorter than 30 days while columns 2 and 4 take only into account maturities longer than 30 days. The purpose of the above regressions is to show whether banks which do not comply with their quantitative liquidity requirement non-Compliant behave differently in the unsecured interbank money market. As required by RDD, we include the distance of an institution's DLCR to the 100% threshold ($DLCR - 100\%$) as well as an interaction term ($Compliance * DLCR$). Additionally, we include Lagged Capital, an institution's LaggedRelationships, Average maturity of the issued loans, the average equity holdings over total assets (Counterparty solvency) and a large number of additional lagged bank-specific variables (capital, size, cds spread, rating, profitability and return on equity) as well as period dummies and GDP growth. To avoid our results to be driven by large outliers, we drop the lowest 1% as well as the highest 99% of all variables Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses.*

**Table 4** – Corporate Lending

| VARIABLES | Long-Term | | | Short-Term | | |
|---|---|---|---|---|---|---|
| Estimation | OLS | RE | FE | OLS | RE | FE |
| (Non-Compliant*IB Rate) | 0.34** | 0.34** | 0.54*** | 0.29* | 0.29* | 0.46*** |
| | (0.17) | (0.17) | (0.20) | (0.16) | (0.16) | (0.13) |
| Non-Compliant | -0.93 | -0.93 | -1.48 | -1.00 | -1.00 | -1.59 |
| | (1.30) | (1.30) | (1.12) | (1.40) | (1.40) | (1.21) |
| IB Rate | 0.06** | 0.06** | 0.05** | 0.07** | 0.07** | 0.08*** |
| | (0.02) | (0.02) | (0.02) | (0.03) | (0.03) | (0.03) |
| Lending standards | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.06 |
| | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) | (0.04) |
| Credit Demand | 0.13*** | 0.13*** | 0.13*** | 0.12*** | 0.12*** | 0.12*** |
| | (0.03) | (0.03) | (0.03) | (0.04) | (0.04) | (0.03) |
| Lagged capital | 0.65*** | 0.65*** | 1.23*** | 0.57*** | 0.57*** | 1.15*** |
| | (0.18) | (0.18) | (0.23) | (0.20) | (0.20) | (0.24) |
| Constant | 2.93*** | 2.93*** | 1.26*** | 4.69*** | 4.69*** | 5.77*** |
| | (0.29) | (0.29) | (0.37) | (0.42) | (0.42) | (0.42) |
| Observations | 410 | 410 | 410 | 402 | 402 | 402 |
| $R^2$ | 0.44 | 0.43 | 0.34 | 0.43 | 0.43 | 0.33 |

*Note: The table presents OLS, random and fixed effects estimations with either the spread between an institution's corporate lending rate and the ECB interest rate or the natural logarithm of an institution's total monthly lending being the dependent variable. The key explanatory variable is $Non-Compliant*IBRate$ reflecting the interaction term between an institution's non-compliance with the liquidity requirement ($Non-Compliant$) and an institution's short-term (columns 1 to 3) or long-term (columns 4 to 6) interbank borrowing rate ($IB Rate$). Additional control variables are an institution's Lending standards measured by its response to the Bank Lending Survey, its perception of credit demand (Credit Demand) as well as lagged equity holdings over total assets ($Lagged Capital$). The analysis includes a large number of additional controls variables, such as the share of loans with maturities shorter than 1 year in loans with maturities longer than 1 year and the share of loans larger than 1 million in loans smaller than 1 million. We further included ratings, cds spreads as well as a number of macroeconomic controls, namely GDP growth and inflation. All regressions include year dummies and robust standard errors. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while robust standard errors are in parentheses.*

**Table 5** – Summary statistics with 0%<DLCR<200%

| Variable | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|
| Short-term borrowing spread | 0.86 | 0.39 | -0.40 | 1.56 |
| Long-term borrowing spread | 1.08 | 0.38 | -0.11 | 2.36 |
| Natural logarithm total short-term borrowing | 16.27 | 1.29 | 11.51 | 18.85 |
| Natural logarithm total long-term borrowing | 17.10 | 1.24 | 11.63 | 19.43 |
| Short-term lending spread | 0.86 | 0.40 | -0.46 | 1.42 |
| Long-term lending spread | 1.10 | 0.38 | -0.15 | 2.12 |
| Natural logarithm total short-term lending | 16.10 | 1.37 | 11.51 | 19.85 |
| Natural logarithm total long-term lending | 17.65 | 1.02 | 14.02 | 19.82 |
| Corporate lending spread | 2.17 | 0.54 | 0.53 | 4.98 |
| Natural logarithm total corporate lending | 6.39 | 1.36 | 0.69 | 8.51 |
| Compliant | 0.91 | 0.15 | 0 | 1 |
| DLCR | 129.26 | 27.36 | 48.27 | 198.84 |
| Lending standards | 2.94 | 0.63 | 1 | 4 |
| Credit demand | 3.06 | 0.76 | 1 | 5 |
| Capital | 2.58 | 1.03 | 1.08 | 10.34 |
| Relationships borrower | 0.26 | 0.26 | 0.00 | 0.84 |
| Relationships lender | 0.21 | 0.22 | 0.00 | 0.76 |
| Counterparty solvency | 1.52 | 1.04 | 2.24 | 9.87 |
| Borrower health | 0.32 | 2.63 | -3.74 | 3.45 |

*Note: The above table shows summary statistics for all relevant variables.*

**Table 6** – Short-term and long-term borrowing rates

| Bandwidth | 99-101 | 90-110 | 85-115 | 80-120 | 50-150 | 0-200 | All |
|---|---|---|---|---|---|---|---|
| Linear no controls | -0.103 | -0.114 | -0.087 | -0.098 | -0.094 | -0.086 | -0.088 |
| | (0.124) | (0.071) | (0.062) | (0.051) | (0.047) | (0.057) | (0.059) |
| Linear controls | -0.124 | -0.086 | -0.098 | -0.098 | -0.094 | -0.081 | -0.066 |
| | (0.457) | (0.482) | (0.387) | (0.590) | (0.674) | (0.484) | (0.494) |
| Linear no controls | -0.118 | -0.117 | -0.096 | -0.124 | -0.128 | -0.118 | -0.097 |
| | (0.165) | (0.006) | (0.072) | (0.065) | (0.048) | (0.043) | (0.044) |
| Linear controls | -0.142 | -0118 | -0.111 | -0.118 | -0.124 | -0.103 | -0.109 |
| | (0.084) | (0.060) | (0.060) | (0.060) | (0.059) | (0.047) | (0.046) |

*Note: The table shows sensitivity analyses for columns 1 and 2 of Table 2. To avoid our results to be driven by large outliers, we drop the lowest 1% as well as the highest 99% of all variables in each bandwidth separately.*

**Table 7** – Short-term and long-term borrowing volumes

| Bandwidth | 99-101 | 90-110 | 85-115 | 80-120 | 50-150 | 0-200 | All |
|---|---|---|---|---|---|---|---|
| Linear no controls | 0.393 | 0.211 | 0.298 | 0.186 | 0.235 | 0.238 | 0.127 |
| | (0.261) | (0.159) | (0.258) | (0.203) | (0.175) | (0.141) | (0.156) |
| Linear controls | 0.521 | 0.374 | 0.363 | 0.331 | 0.344 | 0.274 | 0.183 |
| | (0.451) | (0.209) | (0.198) | (0.206) | (0.208) | (0.168) | (0.174) |
| Linear no controls | -0.603 | -0.401 | -0.318 | -0.354 | -0.311 | -0.294 | -0.278 |
| | (0.311) | (0.202) | (0.179) | (0.132) | (0.114) | (0.094) | (0.108) |
| Linear controls | -0.594 | -0.416 | -0.320 | -0.347 | -0.326 | -0.298 | -0.264 |
| | (0.455) | (0.194) | (0.174) | (0.111) | (0.137) | (0.081) | (0.101) |

*Note: The table shows sensitivity analyses for columns 3 and 4 of Table 2. To avoid our results to be driven by large outliers, we drop the lowest 1% as well as the highest 99% of all variables in each bandwidth separately.*

**Table 8** – Short-term and long-term lending rates

| Bandwidth | 99-101 | 90-110 | 85-115 | 80-120 | 50-150 | 0-200 | All |
|---|---|---|---|---|---|---|---|
| Linear no controls | -0.128 | -0.132 | -0.092 | -0.081 | -0.090 | -0.094 | -0.094 |
| | (0.072) | (0.056) | (0.053) | (0.050) | (0.051) | (0.050) | (0.049) |
| Linear controls | -0.136 | -0.110 | -0.106 | -0.114 | -0.114 | -0.094 | -0.105 |
| | (0.055) | (0.058) | (0.050) | (0.049) | (0.046) | (0.044) | (0.043) |
| Linear no controls | -0.123 | -1.084 | -0.105 | -0.101 | -0.100 | -0.099 | -0.095 |
| | (0.062) | (0.058) | (0.050) | (0.048) | (0.047) | (0.042) | (0.045) |
| Linear controls | -0.130 | -0.124 | -0.115 | -0.125 | -0.116 | -0.117 | -0.097 |
| | (0.078) | (0.064) | (0.057) | (0.046) | (0.049) | (0.046) | (0.046) |

*Note: The table shows sensitivity analyses for columns 1 and 2 of Table 3. To avoid our results to be driven by large outliers, we drop the lowest 1% as well as the highest 99% of all variables in each bandwidth separately.*

**Table 9** – Short-term and long-term lending volumes

| Bandwidth | 99-101 | 90-110 | 85-115 | 80-120 | 50-150 | 0-200 | All |
|---|---|---|---|---|---|---|---|
| Linear no controls | 0.251 | 0.264 | 0.192 | 0.201 | 0.187 | 0.134 | 0.123 |
| | (0.534) | (0.406) | (0.468) | (0.481) | (0.296) | (0.321) | (0.299) |
| Linear controls | 0.249 | 0.258 | 0.247 | 0.194 | 0.204 | 0.139 | 0.141 |
| | (0.568) | (0.398) | (0.501) | (0.467) | (0.343) | (0.297) | (0.308) |
| Linear no controls | 0.563 | 0.412 | 0.359 | 0.344 | 0.309 | 0.301 | 0.264 |
| | (0.200) | (0.201) | (0.194) | (0.194) | (0.140) | (0.131) | (0.124) |
| Linear controls | 0.551 | 0.464 | 0.418 | 0.417 | 0.400 | 0.308 | 0.268 |
| | (0.290) | (0.289) | (0.183) | (0.200) | (0.198) | (0.170) | (0.166) |

*Note: The table shows sensitivity analyses for columns 3 and 4 of Table 3. To avoid our results to be driven by large outliers, we drop the lowest 1% as well as the highest 99% of all variables in each bandwidth separately.*

***A modified version of Lee and Lemieux (2010)***

To illustrate the behavior of the banks in our sample, we can modify the test-taking RDD example, described in Lee and Lemieux (2010). Lee and Lemieux (2010) describe two experiments to explain the intuition behind imprecise control. Both experiments include different types of students, belonging either to Group A or Group B. In the first example, type A students are more capable than type B students and are also, in contrast to type B, aware of the threshold determining whether a student receives a scholarship or not. Lee and Lemieux (2010) further assume that the test in the first example includes trivial questions, but due to random chance students will sometimes make careless mistakes when they initially answer the questions. The questions are, however, easy enough so that students can correct their mistakes when they check their work. In this case, all Group A students would check their answers and thus, the failing students would be exclusively Group B students. In the second example, the questions are not trivial, so that there are no guaranteed passes. In this case, although Group A students can exert more effort, they do not know the exact score they will obtain, resulting in marginally failing and marginally passing students to be comparable.

Drawing the link to our sample, one could think of a modified version of this experiment. Suppose we have two groups of students with Group A students being more capable than Group B students. In contrast to the above example, however, both groups are perfectly aware of the cutoff point and also have some knowledge about their capability. In addition, the test in our example gives students the opportunity to answer an infinite number of questions while the number of required correct answers (for instance 10) to receive the scholarship remains the same. The answering of questions, however, comes at a cost, which can be time or energy. Students therefore face a trade-off between precautionary answering more questions and the opportunity costs of doing so. Given this setup, it seems reasonable to assume that the less capable Group B students will rationally answer more questions, knowing that their number of wrong answers is likely to be larger. The outcome of such behavior is that while we would expect more students above than below the threshold, there should not be a difference between the two groups as a failure to reach a score above the cutoff is caused by an overestimation of skills which is equally likely for Group A and Group B students. While reaching a score above the cutoff is independent of the group one belongs to, we can think of a situation that in case students have almost perfect knowledge of their capabilities, it is likely that the very upper end (i.e. 18 correct answers) consists exclusively of Group B students as Group A students rationally never answer more than 15 questions. Hence, while we do expect banks to be comparable across our sample, it might be the case that we only find banks with very imprecise control over their DLCR to have very high liquidity holdings.