Liquidity Regulation and Bank Lending

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Abstract

Bank liquidity shortages during the global financial crisis of 2007-2009 led to the introduction of liquidity regulations, the impact of which has attracted the attention of academics and policymakers. In this paper, we investigate the impact of liquidity regulation on bank lending. As a setting, we use the Netherlands, where a Liquidity Balance Rule (LBR) was introduced in 2003. The LBR was imposed on Dutch banks only and did not apply to other banks operating elsewhere within the Eurozone. Using this differential regulatory treatment to overcome identification concerns and a difference-in-differences approach, we find that the LBR increased the volume of lending by Dutch banks relative to other banks located in the Eurozone. Increased equity, an inflow of retail deposits and subsequent increase in balance sheet size allowed Dutch banks to increase lending despite having to meet the LBR requirements. The LBR also affected loan composition (with corporate and retail lending increasing more than mortgage lending) and the maturity profile of loan portfolios. Our results have relevance for policymakers tasked with monitoring the impact of liquidity regulations on banks and the real economy.

Keywords: Bank Lending; Basel III; Liquidity Regulation; Liquidity Balance Rule; Liquidity Coverage Ratio; Propensity Score Matching; Quasi-natural experiment.

JEL Classification: G21, G28

1. Introduction

During the global financial crisis of 2007-2009, governments and regulators intervened extensively to provide liquidity support to banks that were unable to meet short-term obligations. Since then, bank liquidity has attracted considerable attention of academics (Calomiris, Heider, and Hoerova, 2014; De Nicolò, 2016; Chiaramonte and Casu, 2017; Chiaramonte, 2018; Bouwman, 2019) as policymakers have introduced rules requiring banks to hold more liquid assets.[1] Proponents of these new regulations contend that by holding more liquid assets, banks become more resilient to sudden balance sheet shocks, and as a consequence can continue lending to households, small and medium-sized enterprises (SMEs) and corporates even during stressed periods (Schmaltz et al., 2014; Boissay and Collard, 2016; Bressan 2018; Hoerova et al., 2018). However, opponents contend that regulatory compliance with liquidity regulations is costly, and could lead banks to reduce lending to households, SMEs and corporates (Cecchetti and Kashyap, 2016; Birn, Dietsch, and Durant, 2017). A growing body of evidence documents that credit supply fluctuations affect the real economy (see Berger, Molyneux and Wilson, 2020 for a comprehensive review). Borrowers that are unable to compensate for a decline in bank credit with alternative funding sources are likely to reduce investment and / or employment (Gan, 2007; Berton et al., 2018). Hence, reductions in credit supply, instigated by regulatory policy changes could negatively affect borrowers with resultant declines in real economic activity. Given the paucity of evidence, ongoing empirical controversies, and the importance for real economic outcomes, in this paper, we investigate the impact of liquidity regulation on bank lending behavior.

A priori, it is unclear whether the introduction of liquidity regulations lead to an increase or decrease in bank lending, given that banks have a myriad of ways to manage liquidity. For example, in order to meet stricter liquidity requirements, banks could increase stable funding (via increased deposit taking or by issuing new equity) and balance sheet size,

[1] In 2010, the Basel Committee on Banking Supervision introduced new capital and liquidity regulations (embodied in Basel III), which were to be phased in between 2014 and 2019. Banks are not only required to hold more capital than before, but must also comply with new liquidity standards. The liquidity standards framework specifies a liquidity coverage ratio (LCR) and a net stable funding ratio (NSFR). The LCR requires banks to operate with sufficient high-quality liquid assets to ensure survival of a stress scenario lasting one month. The net stable funding ratio (NSFR) requires banks to operate with enough sufficient stable funding to ensure the continuance of operations over a one-year horizon.

possibly leading to an increase in lending to households, SMEs and corporates. Alternatively, to avoid holding more liquidity, banks could reduce balance sheet size by shrinking assets, leading to a decrease in lending, and resultant negative consequences for the real economy. Banks could also adjust the composition of loan portfolios toward shorter maturities, in order to improve liquidity without changing balance sheet size.

To assess the impact of liquidity regulation on bank lending, we use the introduction of a liquidity regulation in the Netherlands, known as the Liquidity Balance Rule (LBR) as a setting. Introduced in 2003, the LBR preceded the Basel III Liquidity Coverage Ratio introduced by the Basel Committee on Banking Supervision following the global financial crisis. According to the LBR, banks are required to hold high-quality liquid assets exceeding or equal to net cash outflows over a 30-day stress period. In contrast to the Liquidity Coverage Ratio, the introduction of the LBR in the Netherlands did not occur following a period of financial instability, and so was unlikely to be anticipated in advance by banks and other industry stakeholders (such as shareholders, bondholders, and depositors). The LBR was imposed on Dutch banks only and did not apply to other banks operating elsewhere in other Benelux countries (Belgium and Luxembourg) or the rest of the Eurozone. Using this differential regulatory treatment to overcome identification concerns, we investigate the impact of liquidity regulation on the lending activities of Dutch banks.

Assessing the impact of liquidity regulation on bank lending presents a significant empirical challenge. Liquidity regulations are often part of a broader set of regulatory reforms, which are anticipated in advance by industry stakeholders. Moreover, liquidity regulations such as the Basel III Liquidity Coverage Ratio, tend to be phased-in gradually over an extended period, during which other significant events can take place. Consequently, isolating the impact of liquidity regulation from other significant events that influence bank lending is not a straightforward task. Our research design, which utilizes an unanticipated policy intervention as a quasi-natural experiment and subsequent empirical analysis, allows us to tackle these issues and investigate the impact of liquidity regulation on bank lending.

In order to assess the impact of the LBR on bank lending, we utilize a difference-in-differences framework where we estimate the difference in the behavior of affected banks between the pre-LBR and post-LBR period with the same difference in the behavior of an

unaffected control group of banks. We follow previous literature based on European data (Schepens, 2016) and use a group of matched banks (that share the characteristics of our treated group of Dutch banks prior to the introduction of the LBR to form a control group) drawn from Eurozone countries, where the LBR was not introduced. Specifically, we use propensity score matching in order to avoid potential selection bias (Roberts and Whited, 2013; Atanasov and Black, 2016). In our baseline estimable model, we include bank level characteristics, as well as country time-varying controls that prior literature suggests are important determinants of bank lending. We also ensure our results remain robust to varying the matching parameters.

Our sample period straddles the introduction of the LBR, and comprises unconsolidated balance sheet, off-balance sheet and income statement data for commercial banks covering the period 2000 to 2006 for 12 Eurozone member countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain). The results of our empirical analysis indicate that the introduction of the LBR increased the absolute volume of lending by Dutch banks relative to other Eurozone banks not subject to the rule. On average, the volume of loans extended by affected banks increased by 23.2% relative to their counterparts not subject to the provisions of the LBR. This corresponds to an additional €34.3 billion lending in the economy. Further analysis indicates that additional equity, an inflow of retail deposits and subsequent larger increase in balance sheet size compared to other Eurozone banks, allowed Dutch banks to increase lending despite having to meet the LBR requirements. Hence, while the volume of loans significantly increased, the share of loans in banks' balance sheets remained unchanged after the implementation of the LBR. The introduction of the LBR also altered the composition of affected banks' loan portfolios. Specifically, relative to unaffected counterparts, the stock of corporate and retail loans of Dutch banks increased more than mortgage loans. Dutch banks also granted more loans of shorter maturity relative to their unaffected counterparts. These results indicate that the introduction of the LBR led Dutch banks to re-orientate lending toward more liquid loans.

In a series of additional tests, we assess the robustness of our main results. First, we: modify the number of matched banks; include additional bank-level covariates in the estimation of the propensity scores used to match treated and control banks; and restrict the

pool of countries used to construct the control group of banks. Our main results are robust to these additional tests. Second, we perform a placebo test by assuming falsely that the LBR was introduced in an earlier period. If banks anticipated the introduction of the LBR, we would expect a change in bank lending during this period. The results of this placebo test do not show any evidence of anticipatory effects via changes in bank lending. Finally, we also re-estimate our baseline model using a sample in which the year 2003 (the year of implementation of the LBR) is excluded. Our results remain consistent with the baseline estimations.

Our study contributes to the literature that has investigated the impact of liquidity regulation on bank behavior. Much of the salient literature that has emerged following the global financial crisis, uses dynamic general equilibrium models to investigate the impact of changes to liquidity rules on lending and real economic activity (Macroeconomic Assessment Group, 2010; Angelini et al., 2011; De Nicolo, Gamba and Lucchetta, 2014; Covas and Driscoll, 2014). In general, these studies conclude that the introduction of liquidity regulations reduce bank lending with a resultant negative impact on the real economy. Additional evidence regarding the link between liquidity regulation and bank behavior is also provided by prior literature that focuses on the Dutch Rule (LBR) and the UK Individual Liquidity Guidance (ILG) regulation. In order to comply with LBR requirements, evidence suggests that banks rely on additional deposit funding (Duijm and Wierts, 2016) and decrease long-term lending on the inter-bank market (Bonner and Eijffinger, 2016). In the UK, the introduction of the ILG reduced cross-border lending to both banks and non-financials (Reinhardt et al, 2020).

Our work is most closely related in spirit to that of Banerjee and Mio (2018) who investigate how banks make balance sheet adjustments to comply with the UK ILG regulation. The authors find that banks adjust the composition of both assets and liabilities by increasing the share of high-quality liquid assets and non-financial deposits, while reducing credit to financial institutions and short-term wholesale funding. Moreover, the ILG did not cause banks to reduce the share of loans granted to non-financial firms. Our study augments and complements the work of Banerjee and Mio along two main dimensions. First, we examine bank lending behavior at both an aggregated and disaggregated level, including an analysis of loan type and maturity. We show that the introduction of the LBR led affected banks to change

loan portfolio composition. Specifically, the enactment of the LBR led to an increase in the overall volume of lending, and a re-orientation toward corporate lending. Our findings also show that the impact of liquidity requirements on bank lending is crucially dependent on the availability of stable sources of funding. These findings constitute an important contribution to the literature, given that we provide new evidence suggesting that the introduction of liquidity regulations not only affects the composition of bank loan portfolios, but also leads to banks accumulating more stable funding in the form of deposits and equity. This is of major importance because by increasing the size of banks' balance sheets, liquidity regulation can lead to an increase in credit supply - an issue neglected by previous studies. Second, we complement Banerjee and Mio by using the Netherlands as a setting, where there were no significant stresses on the banking industry immediately before, during or after the introduction of liquidity regulations. This contrasts with the UK setting used by Banerjee and Mio (2018), where the introduction of ILG followed: a regulatory review of liquidity requirements and extensive consultation with industry stakeholders (FSA, 2007, 2008, 2009); a first round of quantitative easing (QE) by the Bank of England, which ceased in January 2010; and preceded the second round of QE, which commenced in October 2011. In contrast, in the present study we focus on a relatively tranquil period where possible contaminating factors such as QE are absent. Our setting is therefore ideally suited to a more general assessment of the impact of sudden introductions of liquidity regulation on bank behavior. Moreover, we document two channels through which liquidity regulation affects bank lending, via an extensive analysis of the structure of bank loan portfolios and funding.

The remainder of the paper is structured as follows. Section 2 discusses relevant literature and presents a set of testable hypotheses. In section 3, we describe the institutional background to the Dutch Liquidity Balance Rule and present the empirical methodology. Section 4 presents the main results of our baseline model along with the results of a series of robustness tests. Section 5 provides a brief summary.

2. Related Literature and Hypotheses

The global financial crisis highlighted the importance of bank liquidity for financial stability, and as an important factor in determining the volume of credit extended by banks to households, SMEs, corporates and governments (Berger, Molyneux and Wilson, 2020).

Liquidity rules introduced following the financial crisis under Basel III are designed to ensure that banks hold enough liquidity to absorb unforeseen shocks. While there is a paucity of research regarding the impact of liquidity regulations, valuable insights are provided by general literature on bank liquidity. Following a seminal contribution by Diamond and Dybvig (1983) showing how depositor runs can affect even healthy banks, theoretical contributions highlight the need for liquidity regulation given bank vulnerabilities arising from asset-liability liquidity mismatches.[2] The remainder of this section reviews prior literature in order to develop testable hypotheses regarding the impact of liquidity regulation on bank lending, loan portfolio composition and funding structure.

Bank lending

Discussions of bank liquidity are relevant to both the liability side and the asset side of the balance sheet. On the liability side of the balance sheet, funding liquidity is a primary concern. Following a liquidity shock, the availability of short-term funding to banks becomes impaired. Banks then face a choice between seeking additional funding and / or shrinking assets. The impact of any negative shock depends upon the composition of liabilities, with banks reliant on wholesale funding impacted more relative to counterparts reliant on stable deposit funding.

Funding liquidity can interact with asset liquidity. Hanson et al. (2015) highlight synergies between the asset and liability sides of the balance sheet, pointing out that banks can readily sell liquid assets in response to a funding shock. Consequently, the ability of banks to handle a funding shock depends upon holdings of liquid assets, as well as the extent of reliance on wholesale funding. Following a funding shock, banks reliant on wholesale funding or holding a larger share of illiquid assets are expected to curtail lending more than counterparts holding a relatively larger proportion of liquid assets, and reliant on stable deposit funding.

The introduction of liquidity rules is likely to cause banks to change the composition of assets and / or liabilities. Banks are likely to reduce illiquid assets and / or increase liquid assets and stable funding sources with resultant implications for bank lending. Prior research documents a positive relationship between liquidity and bank lending, albeit these studies typically investigate this issue through the prism of monetary policy (Kashyap and Stein, 2000;

[2] De Nicolo (2016) provides an extensive discussion and review of the literature regarding the rationale and benefits and costs of liquidity regulation.

Gambacorta, 2005). Agenor (2019) presents a theoretical model where liquidity requirements enhance financial stability, thus increasing confidence among depositors and acting as an incentive to save. This increased saving has a positive effect on banks' ability to lend. Similarly, Reinhardt et al. (2020) offer empirical evidence for the UK of a moderating effect of deposit funding on the impact on cross-border lending following the introduction of liquidity regulations. The authors assert that a dependence on deposit funding could result in a cross-border expansion in lending, despite more onerous liquidity requirements. Nevertheless, Banerjee and Mio (2018) find no change in bank lending following the introduction of liquidity regulation in the UK banking industry.

A small, but growing literature using dynamic structural models offers differing assessments regarding the impact of liquidity rules on bank behavior and real economic activity. These assessments range from a small and negative (Macroeconomic Assessment Group, 2010; Angelini et al., 2011) to a negative and significant impact of liquidity requirements on bank lending and real economic activity (Institute of International Finance 2011; EBA Banking Stakeholder Group, 2012). Tirole (2011) argues that finite horizon (generally three-period) models of the type used in these aforementioned studies capture key trade-offs in a tractable way. However, infinite horizon models that take into account the implied shadow costs faced by banks are likely to deliver more reliable assessments. Building upon this argument, De Nicolo, Gamba and Lucchetta (2014) consider a dynamic partial equilibrium model, in which banks transform insured deposits and short-term collateralized debt into long-term illiquid assets. The results suggest that the introduction of liquidity requirements reduces bank lending, efficiency and welfare. The authors argue that banks use retained earnings to invest in liquid assets rather than extending loans. Covas and Driscoll (2014) develop a similar model in order to assess the macroeconomic impact of bank liquidity requirements. The authors find that the introduction of liquidity standards leads to a decrease in bank lending, albeit the size of this effect is sensitive to the supply of safe assets. Empirical evidence, using quasi-experimental research designs, lends support to the prediction of a more modest impact of liquidity requirements on bank lending. For the Netherlands, Bonner and Eijffinger (2016) document a negative impact of liquidity requirements on interbank lending, but find no impact on lending to non-financial firms. Based upon insights from the aforementioned literature, we offer two alternative hypotheses on the effect of liquidity regulation on bank lending:

H1A: The introduction of liquidity requirements leads to an increase in bank lending.
H1B: The introduction of liquidity requirements leads to a decrease in bank lending.

Loan portfolio structure

Banks face a myriad of lending opportunities that range in type and maturity. Given that liquidity regulation aims to address mismatches in the maturity of assets and liabilities, banks are likely to take account of any potential mismatches when allocating credit across a myriad of lending opportunities. Banks facing liquidity pressure are more likely to favor granting short rather than longer-term loans (Bonner and Eijffinger, 2016). Therefore, we anticipate that banks affected by liquidity regulation are likely to adjust the composition of loan portfolios toward shorter maturities. Based upon insights from the aforementioned literature, our second hypothesis, stated in the alternate, is as follows:

H2: The introduction of liquidity requirements leads to an increase in short term bank lending.

Funding structure

Theory predicts a positive association between liquidity regulation and bank deposits. Two explanations are offered to justify this assertion. The first is that, following the introduction of liquidity regulations, banks attract more funds to alleviate any constraints placed upon lending. Webb (2000) argues that if banks have access to sufficient funding, the implementation of liquidity regulation should not constrain lending. That is, banks use various strategies (including capital accumulation and equity issuance, money market borrowing, offering higher interest rates on deposits) to secure additional funds. Therefore, following the enactment of liquidity regulation, banks may engage in a strategy of actively attracting deposits such as providing new or enhanced services or increasing interest rates on savings. Alternatively, depositors may view banks as safer following the introduction of liquidity regulation. Indeed, liquidity regulation causes banks to hold more liquid assets with a resultant decline in liquidity risk and bank fragility (Vives, 2014). That is, banks holding more liquid assets are more resilient to negative balance sheet shocks (Ratnovski, 2013) and less prone to runs (De Bandt, Lecarpentier and Pouvelle, 2021). Consequently, following the enactment of liquidity regulation, banks may experience an inflow of deposits resulting from the belief that

they are safer. Based upon insights from the aforementioned literature, our third hypothesis stated in the alternate, is as follows:

H3: *The introduction of liquidity requirements leads to an increase in bank deposits.*

Theory offers contrasting views regarding the impact of liquidity regulation on bank capital. One view posits that capital and liquidity are to some extent substitutes, where an increase in liquidity requirements could achieve the same outcome as an increase in capital requirements. That is, to the extent that banks hold higher levels of capital as an incentive to avoid accumulating excessive risks on asset portfolios, maintaining high levels of liquid assets has a similar effect (Kashyap, Tsomocos and Vardoulakis, 2014; Calomiris, Heider and Hoerova, 2014; Acharya, Mehran and Thakor, 2016). Therefore, liquidity regulation can induce banks to reduce capital. An alternative view posits that capital and liquidity are complements rather than substitutes, thus suggesting a positive association between liquidity regulation and capital. In general, returns on liquid assets are lower than those on illiquid assets. This implies that bank profits decline as liquidity increases, leading to an increase in insolvency risk (Eisenbach et al., 2014; Konig, 2015). Consequently, following the introduction of liquidity requirements, banks may increase capital to offset the increase in insolvency risk. Furthermore, liquidity and capital could be associated due to the mechanical link between the two. Indeed, higher capital makes banks more liquid because such funding is stable. Therefore, one way of achieving higher liquidity is to increase capital because it reduces the maturity mismatch between assets and liabilities. Higher liquidity also implies that banks need to hold less capital to comply with capital regulation. Regulatory capital ratios compare equity to asset mix, whereas liquidity ratios compare asset mix to funding mix. For instance, because many liquid assets held on bank balance sheets carry low risk weights in capital requirement computations, banks need less capital to comply with the minimum risk-weighted regulatory capital ratio when they hold larger portions of liquid assets. Based upon insights from the aforementioned literature, we offer two alternative hypotheses on the effect of liquidity regulation on bank capital:

H4A: The introduction of liquidity requirements leads to an increase in bank equity.
H4B: The introduction of liquidity requirements leads to a reduction in bank equity.

3. Background and Research Design

3.1 Identification

To investigate the impact of liquidity regulation on bank lending, we rely on the introduction of the LBR in 2003. The LBR stipulates that banks should hold high-quality liquid assets greater than or equal to net cash outflows over a 30-day stress period.[3] The LBR is defined as: LBR = AL/RL. AL denotes Actual Liquidity, and comprises the sum of the stock of liquid assets and cash inflow scheduled within the next 30 days. RL denotes Required Liquidity, and comprises the sum of the stock of liquid liabilities and cash outflow scheduled within the next 30 days. The LBR ratio should be equal to or exceed one. In order to account for market and funding liquidity risks, items included in AL and RL are weighted according to relative liquidity.[4] During a period of stress, market illiquidity dictates that only certain assets can be sold immediately (often at fire sale prices with resultant losses). In such a situation, the probability of withdrawal may differ depending on the nature of the liability.[5] The period between the announcement and implementation of the LBR was relatively short, thus minimizing the possibility of anticipatory effects and subsequent changes in bank behavior prior to implementation. Announced in January 2003, banks had until July 2003 to comply with the terms of the LBR (de Haan and den End 2013). Every Dutch bank was subject to the rule. Branches of banks located in other countries of the European Union were exempt.

The LBR can be considered as a source of exogenous change in the proportion of liquid to total assets across banks. Given that the rule was introduced in January and implemented in July 2003, there was insufficient time for banks to make any major balance sheet adjustments in order to comply with the rule in advance of implementation.[6] Extensive

[3] The LBR is conceptually similar to the Basel III LCR, which requires banks to hold a minimum level of liquid assets to meet a stress scenario of outflows. The main difference is in the weighting scheme and the range of items included in the stock of liquid assets (which is more extensive for the LBR compared to the LCR).

[4] The weight for each item is determined by the regulator (DNB, 2011).

[5] For example, asset-backed securities carry a lower weight than high-quality bonds. Wholesale deposits carry a higher weight than retail deposits. Liquid assets (such as securities, inter-bank assets payable on demand and debts immediately due or payable by public authorities and professional money-market participants) are items that can be converted to cash quickly. Demand deposits held with non-credit institutions or non-professional money-market participants are not counted as part of the actual liquidity. Liquid liabilities comprise bank debt (such as deposits without a fixed maturity) that can be called upon immediately.

[6] We also conduct an event study analysis, which confirms that the LBR did not affect banks outside of the Netherlands. That is relative to counterparts located elsewhere in the Eurozone, shareholders of Dutch banks

searches of regulatory reports and commentaries suggest there were no information leaks that alerted banks to the pending announcement and provisions of the LBR.[7] Therefore, it is unlikely that banks could have anticipated the LBR.[8] Moreover, other regulatory changes (such as the publication of the preliminary draft of Basel II requirements) that may have occurred at the regional or international level during the period when the LBR was announced and implemented is not expected to affect our analysis.[9] Indeed, such regulatory changes do normally not influence banks differently. At the national level, there were no other changes that could have affected the ability of banks to increase liquidity or lending (IMF, 2004).

The LBR was unique to the Netherlands. Bank regulators based in other Eurozone countries did not consider this type of rule until the Global Financial Crisis of 2007-2009, when following international agreement, the Liquidity Coverage Ratio was introduced (Bonner and Hilbers 2015). Figure 1 shows that the introduction of the LBR led to an increase in liquidity at Dutch banks as expected. Specifically, we observe a levelling off in the volume of liquid assets held by Dutch banks before 2003. It is also evident, that Dutch banks experience a growth in liquid assets after the introduction of the LBR. Nevertheless, the level of liquid assets held by counterparts in neighboring countries exhibit a general downward trend throughout the period considered. This implies that the introduction of the LBR had a positive impact on the liquidity of Dutch banks, while leaving the liquidity of banks located in other Eurozone countries unaffected. Consequently, banks operating in Eurozone countries outside the Netherlands serve as a sample from which a suitable control group can be chosen.

[Insert Figure 1 here]

suffered a greater wealth reduction following the news of the LBR. Nevertheless, these findings rely on a small sample of six publicly listed Dutch banks, which reduces the power of our tests. The results of this event study are available from the authors upon request.

[7] The introduction of a new rule often violates this exogeneity assumption because regulators communicate with industry stakeholders prior to announcement and implementation. If banks anticipate the introduction of a regulation, they may take pre-emptive action to comply or lessen any impacts prior to implementation. Consequently, any change in bank behavior following actual implementation would be negligible.

[8] Dutch banks had relatively high levels of liquidity in the pre-treatment period (IMF 2004). Liquid assets had been high enough to cover 50% of short-term liabilities since 1998.

[9] We thank an anonymous referee for suggesting this clarification.

3.2 Data

We collect financial statement items from the BankScope produced by Bureau van Dijk. This comprises unconsolidated balance sheet, off-balance sheet and income statement data of commercial banks from 2000 to 2006 for the Netherlands and the 11 other European countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Portugal and Spain) forming the Eurozone in 2003 (the year of the introduction of the LBR). We restrict our sample to these countries for two reasons. First, to avoid changes in the composition of any possible control group arising from the accession of new countries to the Eurozone. Second, structural differences between countries should be insignificant, and the banking industry in each country would face the same constraints due to regulation. We complement the bank-level data with macroeconomic data, retrieved from the Eurostat database. A full list of variables and accompanying definitions are provided in Table 1.

[Insert Table 1 here]

Our initial sample comprises 528 banks per year on average. We exclude 12 banks identified as branches of banks located in other Eurozone countries. This leaves us with a sample of 517 banks. To eliminate the undue influence of outliers, we winsorize all bank-specific variables at the 5th and 95th percentile. In order to reduce the possible impact of mergers and acquisitions that took place during the period, we also discard all bank-year observations where growth in total assets exceeds 25%. To deal with reporting errors, we delete observations with negative assets and loans. Applying these filters, leaves us with a final sample that comprises of 473 banks per year on average. Column 1 of Table 2 provides further details on the number of banks by country

[Insert Table 2 here]

3.3. Model Specification

To assess the impact of the LBR on bank lending, we use a difference-in-differences framework, where we estimate the difference in the lending of affected banks between the pre-LBR and post-LBR period with the same difference in the behavior of the unaffected group of banks as follows:

$$Y_{i,t} = \beta(Affected_i \times Post\ Event_t) + \delta X_{i,t-1} + \alpha_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where i indexes bank and t indexes times. $Y_{i,t}$ denotes bank lending, which is measured by lnLOAN, LOANFW and RATLOAN. lnLOAN is the log of total loans (stock of loans). LOANFW is the net flow of loans defined as the change in the stock of loans and unused commitments scaled by total assets and unused commitments as in Cornett et al. (2010). RATLOAN is total loans scaled by total assets. $Affected_i$ is a dummy variable equal to one for banks affected by the LBR (Dutch banks) and zero otherwise. $Post\ Event_t$ is a dummy variable for the treatment period. It takes the value of one for the years 2003 onwards, and zero otherwise. β is the coefficient of interest, which represents the impact of the LBR on bank lending.

$X_{i,t-1}$ represents a vector of both bank- and country-level control variables that prior literature suggests are important determinants of bank lending. In order to avoid simultaneity, we lag each of our control variables by one period. Bank size (SIZE) is measured as the natural logarithm of total assets. The effect of bank size on lending is ambiguous. Large banks may assume more risk than smaller counterparts, given expectations regarding the likelihood of official bailouts (in the event of failure). Moreover, large banks can also diversify asset portfolios, thus holding a lower stock of loans relative to total assets. Consequently, large banks are less likely to reduce loan portfolios in the event of a negative shock (Gambacorta and Marques, 2011; Jiménez et al., 2012; Popov and Van Horen, 2015). In contrast, small banks are likely to specialize in traditional lending activities, and are thus more likely to curtail loans in event of a negative shock to liquidity (Petersen and Rajan 1994; Berger and Udell 1995). Loan quality is measured as the ratio of loan loss reserves to total asset (LLR). Prior evidence suggests that there is a significant negative correlation between loan quality and loan growth (Chami et al., 2010; Stepanyan and Guo, 2011; Cucinelli, 2015). Funding is measured by the ratio of deposits to total assets (DEPOSITS). The importance of stable bank funding for credit supply was illustrated aptly during the global financial crisis of 2007-2009 when banks that were more reliant on traditional deposits maintained lending to households and firms (Cornett, McNutt, and Strahan, 2010; Chami et al., 2010). Consequently, when faced with stricter liquidity requirements, banks more dependent on deposits are more likely to continue lending relative to counterparts more reliant on wholesale funding. Capital (EQUITY) is measured by total equity to total assets ratio. Prior evidence suggests that there is a significant

relationship between capital and lending (Berrospide and Edge 2010; Carlson, Shan, and Warusawitharana 2013; Kapan and Minoiu, 2013). Given the ability to efficiently absorb negative shocks to loan portfolios, well capitalized banks are expected to extend more loans when faced with stricter liquidity requirements. Liquidity is measured by the ratio of liquid-to-total assets (LIQ). Liquid assets for purposes of LIQ are defined as the sum of trading securities, reserve repos, cash collateral, loans and advances to banks, cash and due from banks minus mandatory reserves. Prior evidence suggests that more liquid banks tend to lend more than counterparts holding higher proportions of illiquid assets (Cornett, McNutt, and Strahan, 2010; Kim and Sohn, 2017). Hence, we expect a positive relationship between LIQ and lending. Economic conditions and monetary policy are measured by the real GDP growth (GROWTH) and inflation (INFLATION) respectively. Given that economic conditions determine consumption and investment demand (and thus reflect the demand for credit), higher GDP is likely to related to higher credit growth (Frankel and Romer 1999; Takats 2010). Inflation is likely to negatively impact lending, given that financial intermediaries are less willing to fund new projects in an inflationary environment (Bernanke and Blinder 1988). The model also includes bank specific fixed effects, α_i, to control for unobserved bank heterogeneity and time dummies, λ_t, to capture time effects common to all banks. Table 3 presents the correlation matrix of all variables. The pairwise correlations suggest that the independent variables included in Equation 1 are not highly correlated. Consequently, multicollinearity issues are not a concern.

[Insert Table 3 here]

3.4 Propensity Score Matching

Our sample comprises of 26 Dutch banks and 447 banks from other Eurozone countries. Table 4 provides descriptive statistics for the main variables for both Dutch banks and banks from other Eurozone countries spanning the 2000-2006 period.

[Insert Table 4 here]

Panel A of Table 4 shows that Dutch banks with, on average, assets of € 5.45 billion are larger, have lower loan portfolio quality (measured by LLR; 0.75% versus 0.69%), and extend more loans (lnLOAN 6.85 versus 6.14) than counterparts located in other Eurozone countries.

In addition, Dutch banks experience a smaller decrease in loan growth as well as a slower growth in the ratio of loans to total assets relative to counterparts based in other Eurozone countries during the pre-treatment period. This suggests there are some structural differences across Eurozone banking systems.[10] If Dutch banks differ from control banks in the pre-treatment period across a number of observable characteristics, they might exhibit different trends in the outcome variables of interest in the post-treatment period even in the absence of the LBR. Fortunately, propensity score matching (PSM) can be used to construct a valid control group; thus ensuring comparability between the treatment and control group. In the present study, we follow Roberts and Whited (2013) and Schepens (2016), and use PSM to construct a suitable control group.

Our propensity score matching is executed based upon trends in lending and other balance sheet characteristics as well as national economic conditions in the pre-treatment period (prior to the introduction of the LBR). Specifically, we compute propensity scores using the levels of total assets and total loans. We also use the growth rate in: loans; ratio of total deposits to total assets; ratio of total equity to total assets; real GDP and inflation. Hence, we select banks of similar size, portfolio composition, capital structure and facing similar economic conditions in the pre-treatment period. The propensity scores are used to match each Dutch bank with its three nearest neighbors. The matching is executed with replacement. This means that each non-Dutch bank can serve as a control for multiple Dutch banks, thus improving the accuracy of the matching procedure (Smith and Todd, 2005).

3.5 Summary Statistics of the Matched Sample

The matching procedure leads to a final sample of 85 banks, comprising 22 treated banks and 63 control banks.[11] Column 2 of Table 2 tabulates the countries where banks in our matched sample are headquartered. The impact of the matching is illustrated in Table 5, where summary statistics for the outcome and control variables of the treated and control banks are presented. Panel A of Table 5 shows that the difference in means between Dutch banks and

[10] Goddard, Molyneux and Wilson (2010, 2015, 2019) provide detailed overviews of the banking systems of EU member states before, during and after the global financial crisis.

[11] Four Dutch banks are dropped from our matched sample due to missing values for DEPOSITS; a variable used in the propensity score matching exercise.

the matched group of banks is not statistically significant for all bank characteristics. Moreover, trends in loans to assets ratio (RATLOAN), total loans (lnLOAN) and loans flow (LOANFW) are similar between Dutch banks and matched banks in the pre-treatment period (Panel C). In addition, Panel D shows that in the post-treatment period the growth in two of the three outcome variables, namely lnLOAN and LOANFW, is significantly higher for Dutch banks compared to control banks. Figure 2 provides a graphical illustration of the aforementioned findings. It depicts the evolution of loans, loan flows and loans to total assets for banks in the treatment and control groups. The trends in all outcome variables follow similar paths in the pre-treatment period lending support to the notion that the parallel trends assumption is not violated in our setting (more formal test results are reported in Section 4.3). However, from 2003 (the year LBR came into effect), we observe diverging trends for the affected and control banks. This represents tentative evidence that the introduction of the LBR changed the lending behavior of Dutch banks.

[Insert Table 5]

[Insert Figure 2]

4. Results

4.1 Regression results

Table 6 presents the results of estimating Equation (1). The outcome variables are: log of total loans, lnLOAN (column 1); the ratio of loan flows, LOANFW (column 2); and the ratio of total loans to total assets, RATLOAN (column 3). Each model includes bank-specific control variables to capture any potential shocks in one of the time-varying determinants of bank lending as well as country-specific variables to capture country level changes in economic conditions or fiscal policy.

[Insert Table 6 here]

The coefficient on the interaction term, $Affected_i \times Post\ Event_t$, (which represents the average treatment effect of the LBR on loans granted by Dutch banks) is positive and statistically significant when lnLOAN and LOANFW are the outcome variables of interest. This indicates that the introduction of the LBR has a positive and significant impact on both the

stock and flow of loans. Following the introduction of the LBR, the average stock of loans for Dutch banks was 23.2% higher relative to banks not subject to the provisions of the LBR.[12] With the total sum of credit outstanding in the Netherlands in the pre-treatment period in our sample amounting to €147.9 billion, this translates into an expansion in outstanding credit to €182.2 billion. The flow of loans for Dutch banks was 2.3 percentage points higher relative to banks not subject to the LBR. However, in the estimations using RATLOAN as the outcome variable, the coefficient of interest, β, is positive, but not statistically significant. This indicates that the introduction of the LBR does not affect the loans to total assets ratio. This is in line with prior evidence (Bonner, 2016; Banerjee and Mio, 2018).

Turning to our control variables, the coefficient on SIZE is positive and statistically significant at the 1% for the specification in column 1. This suggests that a 1% increase in SIZE is associated with an average increase of about 1% in the (log) amount of loans (lnLOAN). We also find that better capitalized banks extend more loans (according to specifications in columns 2 and 3). The coefficient on DEPOSITS across all specifications shows that an increase in stable bank funding is associated with growth in loans. For instance, a standard deviation (28.18%) increase in DEPOSITS will increase the stock of loans by 1.77%, while it will also increase the flow of loans and the ratio of loans to total assets by 2.53 and 2.47 percentage points, respectively. We also find that an increase in liquid assets has a positive impact on the flow of loans. This finding is consistent with the view that more liquid banks lend more than counterparts holding a higher proportion of illiquid assets (Cornett, McNutt, and Strahan, 2010; Kim and Sohn, 2017). Moreover, the coefficient on LLR shows that increases in the ratio of loan loss reserves to total assets has no impact on the growth of loans. Finally, we find that improved economic conditions are associated with higher credit growth.

Next, we turn our attention to the structure of bank loan portfolios. The results of our empirical investigation indicate that the introduction of the LBR did not affect the share of loans on the balance sheet of Dutch banks. However, banks may adjust the composition of loan portfolios by shifting from long-term to short-term loans. To that end, we obtain data on

[12] For a dummy variable, we cannot directly interpret the coefficient as capturing the impact of the variable on the dependent variable in percentage terms. Therefore, we follow the transformation discussed by Giles (1982): $100 \times [exp(\hat{\beta} - 0.5V(\hat{\beta})) - 1]$, where $\hat{\beta}$ is the estimated coefficient and $V(\hat{\beta})$ represents its variance. In the remainder of the paper, we use the transformed coefficient to discuss the impact of the LBR.

the maturity of loans granted by both affected and control banks. Specifically, we consider loans classified into four different maturity categories comprising: greater than 5 years, between 1 to 5 years, between 3 to 12 months, and less than 3 months. Subsequently, we normalize the amount of loans in the four maturity categories by total assets. Given the limited availability of data on loan maturities for European banks, we use a smaller sample than that used in the main analysis. We estimate Equation 1 using this restricted sample, while considering the normalized amount of loans in each maturity category as an outcome variable. Table 7 presents the results of this analysis. We find that for the first three maturity categories containing longer-term loans, the coefficient on the interaction term $Affected_i \times Post\ Event_t$ is negative and statistically significant at the 1% level. However, the sign of the coefficient turns positive when the shortest maturity loan category is considered. This is consistent with the view that banks switch to shorter maturity loans in response to the imposition of the LBR.

[Insert Table 7 here]

As a further test of whether banks restructure loan portfolios in response to the LBR, we dis-aggregate total loans into mortgage, retail and corporate loans.[13] Subsequently, we re-estimate Equation (1) using the unrestricted matched sample. We assume that mortgage loans are of longer maturity (DeYoung and Jang 2016), while retail loans and corporate loans are of short to medium-term duration (Cortina, Didier and Schmukler, 2018). The results of this analysis, which are tabulated in Table 8, show a positive and significant impact of the LBR on retail and particularly on corporate loans. Specifically, in the post-treatment period, the stock of mortgage, retail and corporate loans of Dutch banks were on average, respectively, 0.8%, 1.8% and 26.7% higher relative to banks in the control group. The flow of mortgages was 0.2 percentage points lower for Dutch banks relative to banks in the control group, but the flows of retail and corporate loans were, respectively, 0.5 and 2.9 percentage points higher. These findings suggest that following the introduction of the LBR, the share of mortgage loans declined, while corporate loans increased (as Panel C shows).

[13] We use the average distribution presented in reports from the Central Bank of each country included in the control group to dis-aggregate the data on loans for each year of the sample.

[Insert Table 8 here]

Overall, the results presented in this section indicate that following the introduction of the LBR, Dutch banks increased lending relative to counterparts not subject to the LBR. The ratio of loans to total assets did not change while the stock of loans and loan flows increased significantly relative to unaffected banks. This implies that the introduction of the LBR led Dutch banks to re-orientate their asset portfolios toward liquid assets, with an insignificant impact on the share of loans in balance sheet totals. Such adjustments would necessitate Dutch banks increasing liquidity. This could be achieved by equity and debt issuance as a means of funding investment in liquid assets (Webb, 2000). We investigate these possibilities in section 4.2.

4.2 The impact of LBR on the Balance Sheet

In order to examine the evolution of various asset and liability categories following the introduction of the LBR, we estimate the following equation:

$$Y_{i,t} = \beta(Affected_i \times PostEvent_t) + \alpha_i + \lambda_t + \varepsilon_{i,t} \quad (2)$$

The outcome variables, $Y_{i,t}$, are: the ratio of liquid assets to total assets (LIQ); the ratio of securities to total assets (SECU); the ratio of equity to total assets (EQUITY); the ratio of customers deposits to total assets (CUSTD); the ratio of deposits from banks to total assets (BANKD); and the natural logarithm of total assets (SIZE).

Table 9 presents the results of the estimation of Equation 2. On the asset side of the balance sheet, the LBR has a positive and significant impact on liquid assets and securities. In the post-treatment period, the ratio of liquid to total assets and securities to total assets are higher for affected banks relative to unaffected counterparts. On the liability side of the balance sheet, the LBR has a significant and positive effect on the ratio of customer deposits-to-total assets, and the ratio of bank deposits-to-total assets for Dutch banks. The ratio of customer deposits-to-total assets and the ratio of bank deposits-to-total assets are higher for Dutch banks relative to counterparts not subject to the LBR. These findings are in line with prior research showing that following the introduction of the LBR, deposits increased for Dutch banks (Duijm and Wierts, 2016). As discussed in Section 2, theory offers two plausible

explanations for the observed positive impact of LBR on deposits. One being that affected banks could actively attract deposits in an effort to continue extending credit after the implementation of liquidity regulations (Webb, 2000). This explanation is further investigated in Section 4.4. The results of this investigation suggest that banks in our sample do not engage in this strategy. Another explanation offered by theory is that banks holding more liquid assets are less fragile, and more resilient to sudden negative balance sheet shocks (Vives, 2014, Ratnovski, 2017, De Bandt, Lecarpentier and Pouvelle, 2021), and as such perceived as safer by depositors. Therefore, the inflow of deposits may have resulted from the belief that the introduction of the LBR made Dutch banks safer.

It also appears that following the introduction of the LBR, Dutch banks increased equity. The ratio of equity to total assets for the average Dutch bank is higher than the average bank in the control group. Holding more liquid assets reduces returns, which leads to an increase in insolvency risk (Eisenbach et al., 2014; Konig, 2015). As such, banks may increase capital in order to offset the increase in insolvency risk induced by increased liquidity requirements. Nevertheless, the positive association between LBR and equity could be the outcome of an increase in capital, given that capital reduces the maturity mismatch between assets and liabilities, and constitutes a more stable funding. Finally, the results in the final column of Table 8 suggest that Dutch banks grew faster than counterparts not subject to the LBR. The total assets for the average Dutch bank are higher than the total assets for the average bank in the control group.

[Insert Table 9 here]

In contrast to prior evidence (Banerjee and Mio, 2018), our results suggest that the introduction of the LBR led Dutch banks to invest in securities as they experienced a growth in deposits and equity relative to counterparts not subject to the liquidity requirements. These adjustments led to an overall increase in the size of balance sheets. Taken together, these results suggest that following the introduction of the LBR, Dutch banks expanded liabilities relative to counterparts not subject to the liquidity requirements. This allowed them to invest in liquid assets without having to reduce the share of loans in overall asset portfolios.

4.3 Sensitivity Tests

In this section, we examine the robustness of our main results to: variations in the matched sample size; the inclusion of additional independent variables in the matching procedure; restrictions on the geographic coverage of the control group; and the false timing of the introduction of the LBR. Table 10 presents the results of these robustness tests, which use the same bank- and country-level controls, as well as fixed effects as described in Equation (1). For brevity, Table 10 reports only the estimated coefficient and relevant standard errors for the interaction term $Affected_i \times Post\ Event_t$, and presents them in rows instead of columns.

First, we test whether variations in matching affect our baseline results. We vary the number of matched banks from three nearest neighbors to the nearest neighbor only (see row (1)), and then to the five nearest neighbors (see row (2)) and obtain similar results. Second, we add additional bank-specific variables to the matching procedure in order to test whether the matching procedure is biased due to omitted variables. We augment our baseline specification set of controls (comprising total assets, growth rate of loans, growth rate of total deposits to total assets, growth rate of total equity to total assets, lagged value of loans, GDP growth rate and the rate of inflation) with non-interest income share (measured as the ratio of non-interest income to total assets), non-interest expense share (measured as the ratio of non-interest expense to total assets), and return on assets (measured as the ratio of net profits-to-total assets). The results remain qualitatively similar to those reported in Table 6 (see row (3)). Third, we restrict the number of countries from which banks in the control group are selected. Specifically, we consider using Belgium and Luxembourg as the only two countries for the control group. The Netherlands is part of the BENELUX, a historical economic union formed with Belgium and Luxembourg. Countries in close geographic proximity and with long term close economic ties are more likely to share similar characteristics. Consequently, an analysis based on these three countries, is likely to address any omitted variable bias associated with these characteristics.[14] Nevertheless, we are also mindful of the specific nature of the banking system in Luxembourg (which specializes on wealth management) and

[14] The matching procedure leads to a final sample of 41 banks, of which 18 treated Dutch banks and 23 control group banks (14 from Luxembourg and 9 from Belgium).

we conduct a further robustness check using only Belgian banks as our control group.[15] Our results hold (see, respectively, rows (4) and (5)). We also investigate whether our results are driven solely by banks' immediate reaction to the announcement and implementation of the rule in 2003. To this end, we omit observations from year 2003 and use this restricted sample to re-estimate Equation 1. The results, which are reported in row (6) of Table 10, suggest that our main findings hold.

A key identification assumption underlying our identification strategy is that in the absence of treatment the coefficient of interest, β, is zero (the parallel trend assumption). We complement our initial investigation of possible violations of the parallel trend assumption reported in Section 3.5 (Panel C of Table 5 and Figure 2) by conducting a placebo test. In order to investigate the effect of a placebo treatment, we assume falsely that the LBR was introduced in 2001 rather than in 2003. We also re-run the matching procedure based on the full sample of 2001. The matching procedure is the same as that used in the baseline analysis with 1998-2000 as the pre-treatment period. The results of this test, which are presented in row (7), suggest that the parallel trend assumption is not violated and the effects on the outcome variable reported in Table 6 are associated with the introduction of the LBR.

[Insert Table 10 here]

Finally, we test whether variations in matching affect the estimates derived for the different balance sheet items. Table 11 reports the results of the estimations. Again, for brevity we tabulate only the estimated coefficient and relevant standard errors for the interaction term $Affected_i \times Post\ Event_t$, and present them in rows instead of columns. The main results still hold.

[Insert Table 11 here]

4.4 Did banks follow an active policy to attract deposits?

The introduction of the LBR led Dutch banks to increase securities holdings, equity capital and deposits. This suggests that Dutch banks made significant balance sheet

[15] The final sample after running the matching comprises 11 Dutch banks (treated group) and 9 Belgian banks (control group).

adjustments. While the increase in securities investments and equity are the direct result of the deliberate actions of banks, the growth in deposits can occur either passively or following a deliberate price or non-price strategy designed to increase market share. However, if the implementation of the LBR improved confidence, deposits may increase regardless of any deliberate actions on the part of Dutch banks.

To investigate whether Dutch banks have engaged actively in strategies to attract deposits, we examine the impact of the LBR on the deposit rates offered by banks. We assume that an increase in deposit rates would be indicative of an active strategy to attract deposits.[16] To assess the impact of the LBR on deposit rates, we estimate the following equation:

$$Y_{i,t} = \beta_1(Affected_i \times PostEvent_t) + \alpha_i + \lambda_t + \varepsilon_{i,t} \quad (3)$$

The outcome variable, $Y_{i,t}$, is the implicit deposit rate measured as the ratio of interest expense on deposits to total deposits (IMPLICIT). The model is estimated over the 2000-2006 period. Table 12 reports the results.

[Insert Table 12 here]

The coefficient of the interaction term is negative, but not statistically significant. This indicates that the introduction of the LBR did not impact deposit rates offered by the average Dutch bank. Hence, Dutch banks have not engaged in active pricing strategies in order to attract deposits. The implementation of the LBR may have improved depositor confidence, which contributed to higher deposit growth. In turn, this allowed Dutch banks to increase their level of lending.

[16] The fact that banks may actively engage in strategies to attract deposits does not exclude the potential incentive effect of the introduction of the LBR. However, we assume that the effect of the former would be stronger. Given that the design and implementation of the LBR rule was not discussed publicly prior to its introduction, we assume that bank customers do not have full access to information. Hence, we can expect that depositor behaviour does not change in the short term. Moreover, Bonner and Eijffinger (2016) indicate that Dutch banks that were below the required level of liquidity charged lower interest on interbank loans, but paid higher interest on unsecured interbank funding, compared to banks operating above the required level of liquidity. Hence, we expect banks to offer higher rate on deposits as a means to raise funding.

5. Conclusion

This paper investigates the impact of bank liquidity regulation on lending using as a setting, the introduction of the so-called Liquidity Balance Rule (LBR) implemented in the Netherlands in 2003. Using a difference-in-differences approach and propensity score matching techniques (to form an appropriate control group of banks to act as a benchmark for our treated banks), our results indicate that following the introduction of the LBR, Dutch banks increased lending relative to unaffected banks. On average, the net flows of loans were 2.3 percentage points higher than what would have been observed in the absence of the LBR. This led to a significant increase in the total stock of loans for affected banks, relative to counterparts not subject to the regulation. The volume of loans was 23.2% higher relative to counterparts not subject to the LBR. By loan category, Dutch banks modified the structure of their respective loan portfolios. Specifically, Dutch banks extended considerably more loans to the corporate sector, while the increase in retail and mortgage loans, relative to unaffected banks was rather moderate. Corporate loans for Dutch banks on average increased by 30% relative to an average Eurozone bank not subject to the LBR. Dutch banks also made significant adjustments to the liability side of balance sheets by increasing equity. They also experienced a significant inflow of customer deposits, relative to an average Eurozone bank not subject to the LBR. Hence, Dutch banks could maintain lending despite stricter liquidity requirements.

Overall, the results of this study suggest that the imposition of stricter liquidity requirements increased bank lending. Moreover, these stricter regulations appear to have contributed to higher depositor confidence, resulting in overall deposit growth at Dutch banks relative to unaffected banks. Given the similarity between the Dutch LBR and the Basel III Liquidity Coverage Ratio, our results have obvious relevance for policymakers tasked with monitoring the impact of liquidity regulations on banks and the real economy. Specifically, the similarity between the LBR and the Basel III Liquidity Coverage Ratio suggests that the post-crisis liquidity regulations may not be detrimental for bank lending activities and the real economy, as many commentators and bank lobbyists have argued. Taken together with prior evidence regarding the impact of liquidity requirements on bank behavior, our results suggest that banks can rely on diverse strategies to comply with the Basel III Liquidity Coverage Ratio. Banks can increase liquidity by altering balance sheet size or modify the composition of assets

and liabilities. Most importantly, our results suggest that a reduction in bank lending appears unlikely regardless of the strategy banks follow in order to comply with Basel III liquidity coverage requirements.

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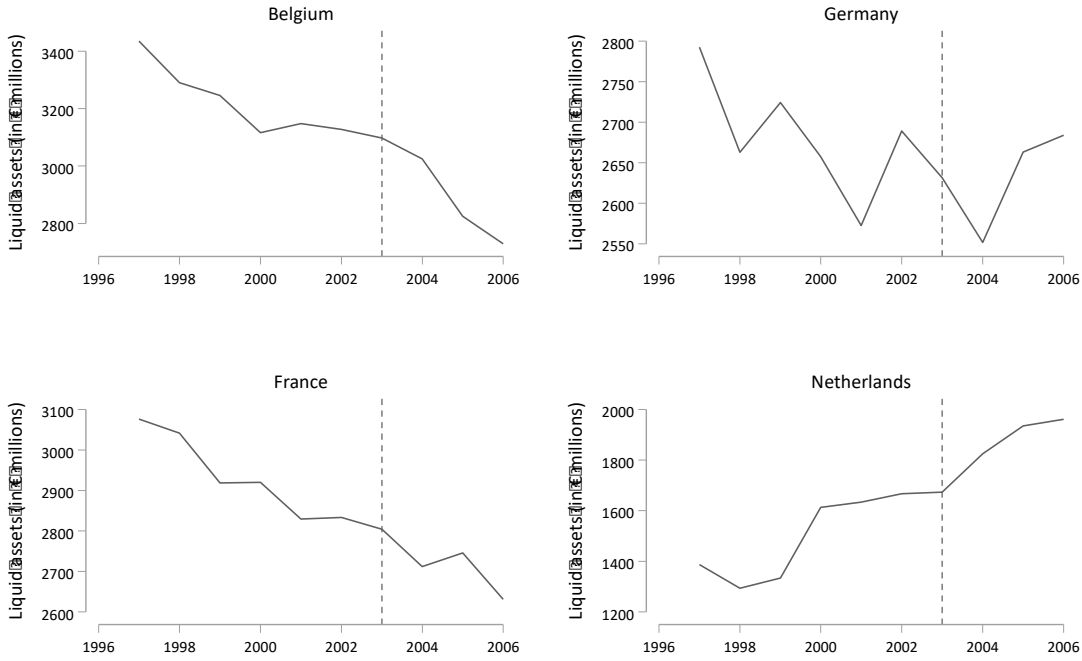
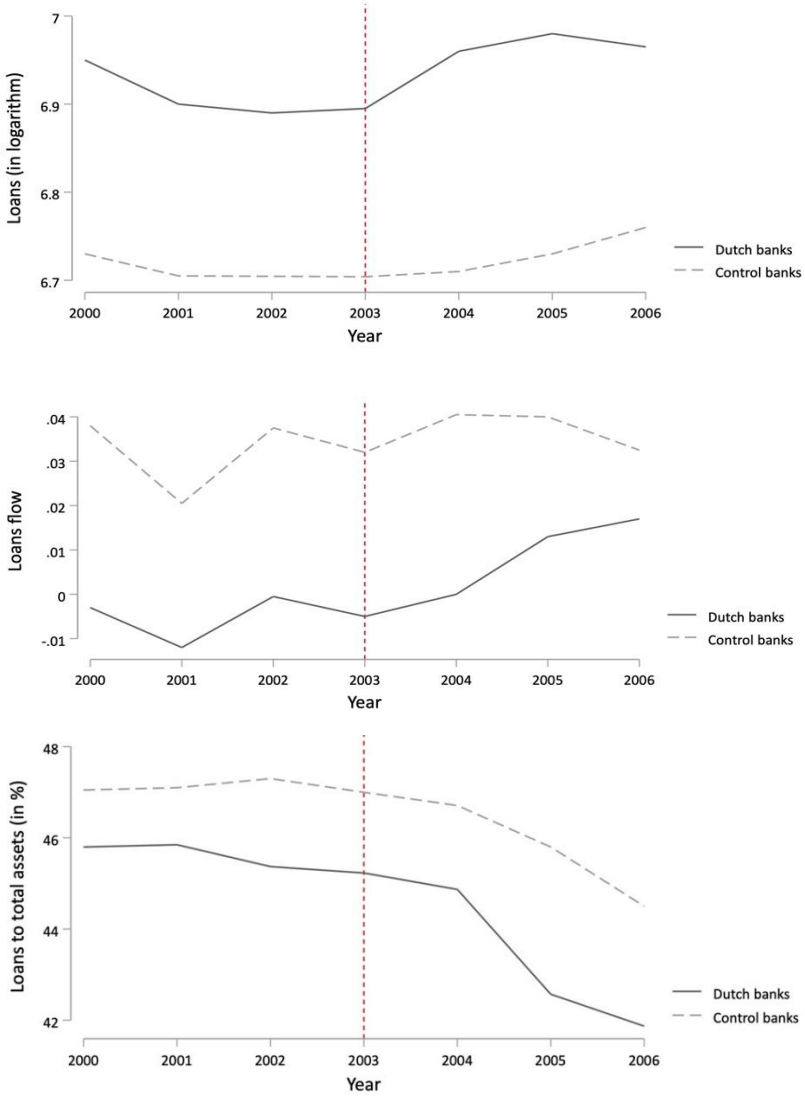
Figures and tables

Figure 1. Evolution of liquid assets (in millions of Euro) of banks in the Netherlands, Belgium, Germany and Luxembourg



Notes: The figure plots the amount of liquid assets (weighted by bank size) held by banks operating in the Netherlands and in neighboring countries (Belgium, France and Germany) included in our full sample.

Figure 2. Evolution of loans, loans flow and loans to total assets from 2000 to 2006



Notes: This figure plots the evolution of loans, loans flow and loans to total assets for both treated and control banks over the period 2000-2006. The dashed vertical line in each graph marks 2003, the year LBR came into effect. The upper graph depicts the mean of loans. The middle graph depicts the mean of loan flows. The bottom graph depicts the mean of loans to total assets. The control group includes all the banks selected via the nearest neighbor matching.

Table 1. Definition of Variables

Variable name	Description	Source	Expected Sign
Dependent variables			
BANKD	Total deposits by banks, including deposits, loans and repos from banks overt total assets (in %)	Bankscope	
CUSTD	Total deposits by customers, including current, saving and term accounts over total assets (in %)	Bankscope	
IMPLICIT	Ratio of interest expense over total deposits (in %)	Computed	
lnLOAN	Natural logarithm of total loans	Computed	
LOANFW	Loans flow defined as the ratio of the year-to-year difference of the sum of net granted loans and unused loan commitments normalized by the sum of total assets and unused loan commitments at the beginning of the period (in %)	Computed	
MAT > 5 years	Ratio of loans with a maturity greater than 5 years to total assets (in %)	Bankscope	
MAT 1-5 year	Ratio of loans with a maturity between 1 to 5 years to total assets (in %)	Bankscope	
MAT 3-12 months	Ratio of loans with a maturity of 3 to 12 months to total assets (in %)	Bankscope	
MAT < 3 months	Ratio of loans with a maturity of less than 3 months to total assets (in %)	Bankscope	
RATLOAN	Ratio of outstanding loans to total assets (in %)	Computed	
SECU	Ratio of the sum of reverse repos, cash collateral, trading securities, derivatives, available for sale securities, held to maturity securities, at-equity investments and other securities over total assets	Bankscope	
Control variables			
DEPOSITS	Total deposits by customers, money market and short-term funding over total assets of bank (in %)	Bankscope	+
EQUITY	Ratio of total equity to total assets (in %)	Bankscope	+
LIQ	Sum of trading securities, reserve repos, cash collateral, loans and advances to banks, cash and due from banks minus mandatory reserves, over total assets of bank (in %)	Bankscope	+
LLR	Ratio of loan loss reserves to total assets (%)	Bankscope	-
SIZE	Natural logarithm of total assets	Bankscope	+/-
GROWTH	Year-to-year growth rate of real GDP	Eurostat	+
INFLATION	Year-to-year growth rate of harmonized price index	Eurostat	-
Other variables			
COMMIT	Total of any undrawn credit facilities made available by the bank (in millions of euros)	Bankscope	
LOANS	Outstanding loans on bank's balance sheet (in millions of euros)	Bankscope	

Notes: This table presents definitions for all variables used throughout the paper. The first column shows the name of the variable as used throughout the paper, the second describes the corresponding definition and the third column gives the source. The final column presents the expected sign for each of the control variables included in the baseline model.

Table 2. Distribution of Banks in the Sample by Country

	Number of banks	
Country	Initial sample	Matched sample
	(1)	(2)
Western Europe		
Austria	38	5
Belgium	20	2
France	92	16
Germany	88	11
Ireland	13	3
Italy	81	2
Luxembourg	52	14
Netherlands	26	22
Southern Europe		
Greece	12	1
Portugal	12	2
Spain	31	6
Northern Europe		
Finland	8	0

Notes: This table indicates for each country the number of banks included in the sample.

Table 3. Correlation Matrix

	1.	2.	3.	4.	5.	6.	7.	9.	10.	11.
1. lnLOAN	1.00									
2. LOANFW	0.12	1.00								
3. RATLOAN	0.17	0.27	1.00							
4. SIZE	-0.19	0.03	-0.19	1.00						
5. DEPOSITS	0.03	-0.18	0.04	-0.15	1.00					
6. LLR	-0.07	-0.04	-0.09	-0.08	0.03	1.00				
7. EQUITY	-0.14	0.07	-0.16	-0.09	-0.44	-0.02	1.00			
8 GROWTH	-0.24	-0.21	-0.24	0.06	0.33	0.15	-0.15	1.00		
9. INFLATION	-0.06	-0.30	-0.06	-0.13	0.27	0.29	-0.18	0.20	1.00	
10. LIQ	-0.63	-0.03	-0.63	0.14	-0.10	-0.21	0.02	0.02	-0.08	1.00

Notes: This table reports the correlation matrix for the outcome variables and control variables used in our analysis.

Table 4. Summary Statistics of the Full Sample

	Dutch banks			Rest of Eurozone				
Panel A: Pre LBR period (2000-2002)								
Variables	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Diff.	p-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RATLOAN	74	45.46	22.88	1180	46.94	27.1	-1.48	0.47
lnLOAN	74	6.85	1.88	1180	6.14	2.13	0.71	0.00
LOANFW	74	0.06	0.22	1180	0.06	0.17	0.00	0.64
SIZE	74	7.71	1.59	1180	7.26	1.7	0.45	0.02
LIQ	74	32.64	21.95	1180	31.75	23.75	0.89	0.73
DEPOSITS	69	46.58	28.18	1068	50.56	23.72	-3.98	0.25
EQUITY	74	10.19	12.22	1180	9.69	12.47	0.5	0.73
COMMITS	74	338.66	666.12	1180	270.82	742.48	67.84	0.39
LLR	63	0.75	0.61	1068	0.69	0.81	0.06	0.01
GROWTH	3	1.43	0.93	33	2.07	2.07	-0.64	0.00
INFLATION	3	0.47	0.56	33	0.59	0.61	-0.12	0.00
Panel B: Post LBR period (2003-2006)								
RATLOAN	103	42	24.17	1602	45.53	28.08	-3.53	0.00
lnLOAN	103	6.67	2.35	1602	6.36	2.13	0.31	0.00
LOANFW	103	0.03	0.17	1602	-0.06	0.15	0.09	0.00
SIZE	103	7.97	1.38	1602	7.45	1.68	0.52	0.000
LIQ	103	32.98	20.84	1602	31.04	24.18	1.94	0.05
DEPOSITS	103	53.19	27.01	1431	51.82	24.22	1.37	0.64
EQUITY	103	9.5	6.27	1602	9.72	12.39	-0.22	0.49
COMMITS	103	382.73	745.91	1602	368.31	871.57	14.42	0.65
LLR	85	0.95	1.44	1584	0.82	0.72	0.13	0.00
GROWTH	4	1.46	0.4	44	2.09	2.08	-0.63	0.00
INFLATION	4	0.4	0.47	44	0.6	0.63	-0.2	0.27
Panel C: Pre-trend (growth in) (%)								
RATLOAN	74	1.97	3.72	1180	3.53	2.16	-1.56	0.00
lnLOAN	74	-0.58	1.74	1180	-1.32	1.81	0.74	0.00
LOANFW	74	-3.28	3.37	1180	-2.91	6.30	-0.37	0.95
Panel D: Post-trend (growth in) (%)								
RATLOAN	103	-2.53	3.16	1602	-1.21	1.87	-1.32	0.00
lnLOAN	103	2.62	2.79	1602	1.34	2.01	1.28	0.00
LOANFW	103	4.45	1.08	1602	1.91	1.14	2.54	0.00

Notes: Panels A and B report summary statistics for all the outcome and control variables for Dutch banks and non-Dutch banks for the full sample over the pre- and post-treatment period respectively. Panels C and D present trends in the pre- and post-treatment period and the mean comparison of these trends between treated and control banks for the outcome variables. Columns 7 and 8 report the differences and p-values for the difference in means test (t-test) between Dutch and Eurozone banks.

Table 5. Summary Statistics of the Matched Sample

	Dutch banks			Rest of Eurozone				
Panel A: Pre LBR period (2000-2002)								
Variables	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Diff.	p-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RATLOAN	57	45.67	21.96	167	46.53	23.77	-0.86	0.55
lnLOAN	57	6.85	1.88	167	6.72	2.17	0.13	0.62
LOANFW	57	0.07	0.22	167	0.05	0.14	0.02	0.45
SIZE	57	7.93	1.37	167	7.81	1.69	0.12	0.54
LIQ	57	31.7	20.91	167	31.56	23.83	0.14	0.69
DEPOSITS	57	46.58	28.18	167	47.45	23.27	-0.87	0.45
EQUITY	57	8.38	4.72	167	8.19	11.67	0.19	0.84
COMMITS	57	335.32	615.27	167	287.15	743.48	48.17	0.19
LLR	57	1.01	0.72	167	0.91	0.68	0.1	0.25
GROWTH	3	1.43	0.93	33	2.07	2.07	-0.64	0.00
INFLATION	3	0.47	0.56	33	0.59	0.61	-0.12	0.00
Panel B: Post LBR period (2003-2006)								
RATLOAN	76	43.29	24.64	248	45.54	22.71	-2.25	0.27
lnLOANS	76	7.51	2.87	248	6.77	2.08	0.74	0.00
LOANFW	76	0.03	0.34	248	0.00	0.12	0.03	0.02
SIZE	76	8.13	1.88	248	7.88	1.67	0.25	0.00
LIQ	76	33.67	23.87	248	31.52	25.26	2.15	0.16
DEPOSITS	76	54.63	27.68	248	48.04	23.69	6.59	0.51
EQUITY	76	9.78	7.56	248	8.25	11.21	1.53	0.23
COMMITS	76	374.27	755.36	248	368.31	751.57	5.96	0.39
LLR	76	1.11	0.84	248	3.259	1.12	-2.149	0.07
GROWTH	4	1.46	0.4	44	2.09	2.08	-0.63	0.00
INFLATION	4	0.4	0.47	44	0.6	0.63	-0.2	0.27
Panel C: Pre-trend (growth in) (%)								
RATLOAN	57	1.63	2.21	167	2.02	2.91	-0.39	0.28
lnLOAN	57	-1.06	2.07	167	-0.93	2.36	-0.13	0.31
LOANFW	57	-3.14	3.87	167	-3.01	1.86	-0.13	0.55
Panel D: Post-trend (growth in) (%)								
RATLOAN	76	-1.94	1.52	248	-1.73	1.23	-0.21	0.81
lnLOAN	76	2.36	2.28	248	0.36	2.68	2.00	0.00
LOANFW	76	3.25	1.27	248	1.23	1.96	2.02	0.03

Notes: Panels A and B report summary statistics for all the outcome and control variables for Dutch banks and non-Dutch banks for the matched sample over the pre- and post-treatment period respectively. Panels C and D present trends in the pre- and post-treatment period and the mean comparison of these trends between treated and matched banks for the outcome variables. Columns 7 and 8 report the differences and p-values for the difference in means test (t-test) between Dutch and matched Eurozone banks.

Table 6. Regression Results: Baseline Model

Variables	lnLOAN	LOANFW	RATLOAN
	(1)	(2)	(3)
Affected × Post Event	0.213**	0.023**	0.011
	(0.092)	(0.008)	(0.015)
SIZE	1.018***	0.027	0.033
	(0.021)	(0.039)	(0.048)
DEPOSITS	0.0631**	0.090**	0.088*
	(0.0242)	(0.021)	(0.052)
LIQ	0.1216	0.022**	-0.137
	(0.1839)	(0.0072)	(0.245)
EQUITY	0.2982	0.075*	0.013**
	(1.3448)	(0.0394)	(0.006)
LLR	-0.0404	-0.038	-0.036
	(0.0984)	(0.2189)	(0.051)
GROWTH	0.055**	0.034**	0.014*
	(0.021)	(0.012)	(0.006)
INFLATION	-0.023	-0.004	0.027
	(0.039)	(0.005)	(0.039)
Year fixed effects	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes
Observations	471	471	471
R-squared	0.923	0.392	0.902

Notes: This table analyses the impact of the introduction of the Liquidity Balance Rule in the Netherlands in 2003 on bank lending behavior. The sample consists of 22 Dutch banks and 63 Eurozone banks selected via propensity score matching. All models are estimated using ordinary least squares and include bank and year fixed effects as well as time-varying bank- and country-level controls: log of total assets, total deposits to total assets, liquid assets to total assets, equity to total assets, loan loss reserves to total assets, real GDP growth and inflation rate, all lagged by one period. *Affected* is a dummy variable equal to one for banks affected by the LBR (Dutch banks) and zero otherwise. *Post Event* is a dummy variable that takes the value of one for the years 2003 onwards, and zero otherwise. The dependent variable is the log of total loan volume in Column 1, the year-to-year variation of the sum of total loans and unused commitments over the lagged sum of total assets and unused commitments in Column 2, and the ratio of total loans to total assets in Column 3. The effect of LBR is captured by the coefficient on the interaction term *Affected × Post Event*. Standard errors are clustered at the bank level and presented in parentheses. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 7. Impact of LBR on Loan Maturity

Variables	MAT > 5 years (1)	MAT 1-5 years (2)	MAT 3-12 months (3)	MAT < 3 months (4)
Affected × Post Event	-0.010***	-0.005***	-0.001***	0.011***
	(0.000)	(0.001)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Observations	202	202	202	202
R-squared	0.943	0.932	0.936	0.945

Notes: The table analyses the impact of the introduction of the LBR on loans by maturity. The sample consists of 12 banks from the Netherlands and 21 matched banks over the 2000-2006 period. All models are estimated using ordinary least squares and include bank and year fixed effects as well as time-varying bank- and country-level controls: log of total assets, total deposits to total assets, liquid assets to total assets, equity to total assets, loan loss reserves to total assets, real GDP growth and inflation rate, all lagged by one period. Affected is a dummy variable equal to one for banks affected by the LBR (Dutch banks) and zero otherwise. Post Event is a dummy variable that takes the value of one for the years 2003 onwards, and zero otherwise. Columns (1) reports the results for loans with a maturity higher than 5 years, while column (2) shows the results for loans with a maturity between 1 to 5 years. Columns (3) and (4) report the results for loans with a maturity between 3 to 12 months and less than 3 months, respectively. All outcome variables are normalized by total assets. The effect of LBR is captured by the coefficient on the interaction term Affected × Post Event. Standard errors are clustered at the bank level and presented in parentheses. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 8. Impact of LBR on Loan Categories

Variables	Panel A : lnLOAN			Panel B : LOANFW			Panel C : RATLOAN		
	MORT	RETL	CORP	MORT	RETL	CORP	MORT	RETL	CORP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Affected × Post Event	0.008**	0.018*	0.267**	-0.002**	0.005***	0.029**	-0.001***	0.001	0.003***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.014)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	471	471	471	471	471	471	471	471	471
R-squared	0.772	0.706	0.663	0.598	0.658	0.523	0.663	0.746	0.802

Notes: This table analyses the impact of the introduction of the Liquidity Balance Rule on the main components of loans portfolio (mortgage, retail and corporate). The sample consists of 22 Dutch banks and 63 Eurozone banks selected via propensity score matching over the 2000-2006 period. In Panel A, the outcome variable is the volume of loans classified either into mortgage, retail or corporate loans category. The outcome variables considered in Panel B, are the flows of loan again disaggregated into three categories. Panel C presents results when the outcome variable is one of the three loan categories normalized by total assets. All models are estimated using ordinary least squares and include bank and year fixed effects as well as time-varying bank- and country-level controls: log of total assets, total deposits to total assets, liquid assets to total assets, equity to total assets loan loss reserves to total assets, real GDP growth and inflation rate, all lagged by one period. The effect of LBR is captured by the coefficient on the interaction term *Affected × Post Event*. Standard errors are clustered at the bank level and presented in parentheses. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 9. Impact of LBR on Bank Balance Sheets

Variables	LIQ	SECU	CUSTD	BANKD	EQUITY	SIZE
	(1)	(2)	(3)	(4)	(5)	(6)
Affected × Post Event	0.017***	0.012***	0.045***	0.004***	0.003***	0.117**
	(0.002)	(0.000)	(0.015)	(0.001)	(0.001)	(0.006)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	471	471	186	186	471	471
R-squared	0.871	0.937	0.983	0.933	0.656	0.932

Notes: This table analyses the impact of LBR on various balance sheet items. Columns 1 and 2 report results for the ratio of liquid assets to total assets (LIQ) and the ratio of total securities to total assets (SECU). Columns 3 and 4 report results for the ratio of customer deposits (CUSTD) and bank deposits (BANKD) relative to total assets. Column 5 presents results for the equity to total assets ratio (EQUITY). Column 6 examines the effect of LBR on the (log of) total assets (SIZE). The sample consists of banks from The Netherlands and their matched non-Dutch banks over the 2000-2006 period. The effect of the LBR is captured by the coefficient of *Affected × Post Event*. Standard errors are clustered at the group level and reported in parentheses. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 10. Impact of LBR on Bank Lending: Sensitivity Tests

		Dependent variables		
		lnLOAN	LOANFW	RATLOAN
(1)	Matching with one neighbor	0.167**	0.011**	0.019
		(0.061)	(0.004)	(0.024)
(2)	Matching with five neighbors	0.156**	0.027***	-0.012
		(0.059)	(0.009)	(0.014)
(3)	Additional matching variables	0.148***	0.024**	-0.043
		(0.058)	(0.009)	(0.053)
(4)	Matching with Benelux countries only	0.153**	0.011**	0.031
		(0.056)	(0.004)	(0.041)
(5)	Matching with Belgium only	0.136*	0.019**	0.063
		(0.081)	(0.006)	(0.088)
(6)	Year of LBR introduction omitted	0.196**	0.021***	-0.038
		(0.079)	(0.008)	(0.054)
(7)	Placebo test	-0.087	0.061	-0.011
		(0.112)	(0.077)	(0.025)

Notes: The table presents the sensitivity of the baseline model to variations in the sample size and matching procedure as well as false timing of the introduction of the LBR. The dependent variables are stock of total loans (lnLOAN), loans flow (LOANFW), and the ratio of loans to total assets (RATLOAN). For brevity, we only report the estimated coefficients of the variable of interest *Affected × Post Event*. Standard errors for the same coefficient are clustered at the bank level and reported underneath in parentheses. The bank- and country-level controls as well as fixed effects are identical to those in columns (1), (2) and (3) of Table 6. Rows (1) and (2) match each Dutch bank with one and five unaffected banks, respectively. Row (3) saturates the matching procedure with additional bank-specific variables. Rows (4) and (5) restrict the number of countries from which banks in the control group are selected to Benelux (i.e. Belgium and Luxembourg) and Belgium, respectively. Row (6) omits the year 2003 (the year LBR was enacted) from the sample. Row (7) conducts a placebo test by falsely assuming the LBR was implemented in 2001 rather than 2003. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 11. Impact of LBR on Bank Balance Sheets: Sensitivity Tests

		Dependent variables					
		LIQ	SECU	CUSTD	BANKD	EQUITY	SIZE
(1)	Matching with one neighbor	0.015**	0.014***	0.053***	0.005***	0.004***	0.139**
		(0.005)	(0.006)	(0.015)	(0.002)	(0.001)	(0.053)
(2)	Matching with five neighbors	0.012***	0.012**	0.047***	0.004***	0.003***	0.115**
		(0.004)	(0.005)	(0.012)	(0.001)	(0.001)	(0.047)
(3)	Additional matching variables	0.007***	0.008**	0.027***	0.003***	0.002***	0.078**
		(0.002)	(0.004)	(0.008)	(0.001)	(0.001)	(0.030)
(4)	Matching with Benelux countries only	0.009**	0.007***	0.037***	0.002***	0.002***	0.089***
		(0.003)	(0.003)	(0.011)	(0.001)	(0.001)	(0.034)
(5)	Matching with Belgium only	0.012**	0.008***	0.019***	0.002**	0.002**	0.061***
		(0.004)	(0.003)	(0.001)	(0.001)	(0.001)	(0.014)
(6)	Year of LBR introduction omitted	0.011***	0.011***	0.032***	0.004***	0.002***	0.114***
		(0.003)	(0.004)	(0.009)	(0.001)	(0.001)	(0.032)
(7)	Placebo test	-0.005	0.005	-0.018	-0.001	0.001	-0.054
		(0.016)	(0.018)	(0.029)	(0.002)	(0.002)	(0.082)

Notes: The table presents the sensitivity of the results regarding the impact of LBR on the banks' balance sheets to variations in the sample size and matching procedure as well as false timing of the introduction of the LBR. The dependent variables are the ratio of liquid assets to total assets (LIQ), the ratio of securities to total assets (SECU), the ratio of customer deposits to total assets (CUSTD), ratio of bank deposits to total assets (BANKD), the ratio of equity to total assets (EQUITY), and the log of total assets (SIZE). For brevity, we only report the estimated coefficients of the variable of interest *Affected × Post Event*. Standard errors for the same coefficient are clustered at the bank level and reported underneath in parentheses. The fixed effects are identical to those in columns (1) to (6) of Table 8. Rows (1) and (2) match each Dutch bank with one and five unaffected banks, respectively. Row (3) saturates the matching procedure with additional bank-specific variables. Rows (4) and (5) restrict the number of countries from which banks in the control group are selected to Benelux (i.e. Belgium and Luxembourg) and Belgium, respectively. Row (6) omits the year 2003 (the year LBR was enacted) from the sample. Row (7) conducts a placebo test by falsely assuming the LBR was implemented in 2001 rather than 2003. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 12. Impact of LBR on the Implicit Interest Rates of Deposits

Variables	IMPLICIT
Affected × Post Event	-0.0256
	(0.031)
Year fixed effects	Yes
Bank fixed effects	Yes
Observations	342
R-squared	0.908

Notes: The table analyses the impact of the LBR on the implicit interest rate of bank deposit measured as the ratio of interest expense on deposits to total deposits in a difference-in-difference set up. The sample consists of banks from The Netherlands and the matched non-Dutch banks over the 2000-2006 period. The effect of the LBR is captured by the coefficient of the interaction term *Affected × Post Event*. Standard errors are clustered at the bank level and reported in parentheses. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.