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Liquidity Regulation and Bank Risk

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Abstract

We investigate the impact of liquidity requirements on bank risk. We take advantage of the implementation of the Liquidity Balance Rule (LBR) in the Netherlands in 2003 and analyze its impact on bank default risk. 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, we find that following the introduction of the LBR, the risk of Dutch banks declined relative to unaffected peers. Despite the lower cost of funding following the enactment of the LBR, the profitability of Dutch banks decreased (in comparison with to unaffected counterparts) as a result of a decrease in non-interest income. Our findings also indicate that better financing conditions allowed Dutch banks to increase the shares of deposits and capital on the liability side of their balance sheets.

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1. Introduction

Until the liquidity shortages that occurred upon the onset of the global financial crisis (GFC) of 2007-2009, scant attention was paid to the importance of liquidity for bank risk. Since then, coordinated international agreements under the auspices of the Basel Committee on Banking Supervision (Basel III standards) have required banks to enhance liquidity via adherence to: a Liquidity Coverage Ratio (LCR), which requires that banks hold enough high-quality liquid assets to survive a stress scenario spanning a one-month duration; and a Net Stable Funding Ratio (NSFR) that requires banks hold a minimum amount of stable funding to withstand a closure of wholesale funding markets (Basel Committee on Banking Supervision, 2009, 2013). Given the importance of liquidity for individual banks, the broader banking industry, and the real economy, this study investigates the impact of liquidity regulation on bank risk.

Given that banks have myriad ways to manage liquidity, it is unclear whether the introduction of liquidity regulations aimed at reducing the maturity mismatch between illiquid assets and liquid liabilities leads to an increase or decrease in bank risk (DeYoung and Jang, 2016).[2] On the one hand, liquidity regulation that requires banks to hold higher levels of liquid assets as a buffer against liquidity shocks leads to a subsequent decline in risk and the probability of bank runs (Diamond and Kashyap, 2016). Moreover, liquidity regulation similar to that introduced under Basel III allows banks to comply with regulatory requirements via increases in capital (Hartlage, 2012). Thus, bank resilience to adverse balance sheet shocks also improves (Hoerova et al., 2018). Banks can also swap funding from sources (such as wholesale funding) that are less favored by liquidity regulation with sources (such as retail deposits) attracting more favorable regulatory treatment. In doing so, banks can reduce the cost of capital, increase profitability, and accumulate capital buffers to withstand external shocks to balance sheets.

On the other hand, holding more retail deposits may increase bank risk in the presence of safety-net guarantees, such as deposit insurance schemes (Lambert et al. 2017; Wagner 2017). The introduction of liquidity regulation may also force banks to increase investments in more liquid but lower-yielding assets, leading to a subsequent decline in profitability. Faced

[2] Bonner et al. (2015) use data from 30 countries and find that the correlation between bank liquidity, market concentration, and bank size are weaker in countries with formal liquidity regulation. The authors contend that liquidity regulations act as substitutes for active liquidity management and limit excessive risk-taking by banks.

with declining profitability, banks may invest remaining funds in riskier investments in order to boost returns (Hoerova et al., 2018; Bosshardt et al. 2021). Consequently, the introduction of liquidity regulation can lead to an increase in bank risk. Ultimately, the impact of liquidity regulation on bank risk is an empirical question – one which we seek to answer in the present study.[3]

Assessing the impact of liquidity regulations on bank risk is not straightforward, given that such rules are often introduced and phased in alongside other forms of safety and soundness regulation. In the present study, we overcome these challenges via a research design that uses an unanticipated policy change as a quasi-natural experiment to investigate the impact of liquidity regulation on bank risk. Specifically, we consider the Liquidity Balance Rule (LBR) introduced in the Netherlands in 2003 as a setting. Under the terms of the LBR, banks are required to hold sufficient high-quality liquid assets to withstand net cash outflows over a 30-day stress period. Therefore, the LBR is similar to the more recently introduced Liquidity Coverage Ratio (LCR). However, contrary to the LCR, the introduction of the LBR did not occur following a period of financial instability. Thus, it was unlikely to be anticipated in advance by banks and other industry stakeholders (such as shareholders, bondholders, depositors). The LBR was imposed on Dutch banks only and did not apply to other banks operating elsewhere in other Benelux countries (Belgium, Luxembourg) or the rest of the Eurozone. To overcome identification concerns we use this differential regulatory treatment and investigate the impact of liquidity regulation on the risk of Dutch banks.

We use a difference-in-differences approach where we estimate the difference in the risk of affected banks between the pre-LBR and post-LBR period, with the same difference in the risk of a control group of banks. To avoid potential selection bias, we follow prior literature based on European data (Schepens, 2016; Ananou et al., 2021) and use propensity score matching to form a control group of similar banks, which are drawn from Eurozone countries where the LBR was not enacted. We also restrict the control group to banks from other Benelux countries and later to banks from Belgium only. Our baseline model includes bank-

[3] In common with capital regulation, the extent to which liquidity regulation affects bank risk is closely linked to profitability. An essential feature of Basel III is the addition of liquidity requirements to capital requirements. While there is an extensive literature investigating the impact of capital regulation on bank risk (Koehn and Santomero, 1980; Kim and Santomero, 1988; Gjerde and Semmen, 1995; Fegatelli 2010; Anginer et al., 2021, among others), to our knowledge, the present study is the first to investigate empirically the impact of liquidity regulation on bank risk.

level characteristics, and country time-varying controls that prior literature considers important determinants of bank risk. We use accounting-based measures of bank risk comprising the standard deviation of the return on assets and a bank default risk (Z-score) measure along with its asset and leverage risk sub-components. Market-based indicators are also constructed for a sub-sample of listed banks using the standard deviation of bank daily stock returns over a calendar year; and a market-based version of bank default risk. The sample period straddles the introduction of the LBR. Our data set comprises unconsolidated balance sheet, off-balance-sheet and income statement data for commercial banks covering the period 1998 to 2008 for 12 Eurozone member countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain).

Our baseline results show that following the introduction of the LBR, both the risk (measured by asset risk or stock price volatility) and default risk of Dutch banks decrease relative to counterparts not subject to the LBR. We augment our baseline analysis with an impulse response function analysis where we examine the dynamic effects of liquidity regulation on bank risk and profitability. The results of this analysis show that the impact on bank risk diminishes over a five-year period following the introduction of the LBR. Moreover, the decline in bank default risk occurs primarily via a reduction in leverage, as banks become better capitalized. These findings are consistent across both accounting and market-based indicators of bank risk. Although the systematic risk of Dutch banks remains unchanged following the introduction of the LBR, their specific risk decreases relative to other banks not subject to the provisions of the LBR. This is particularly pronounced for banks with low levels of liquidity.

In a series of additional tests, we investigate the impact of the introduction of the LBR on bank profitability, cost of funding and funding structure. Our findings indicate that following the enactment of the LBR, Dutch banks alter their funding structure by increasing capital and deposits. We also find that profitability declines despite reduced funding costs. This is driven by a decline in interest revenue at Dutch banks. Nevertheless, the impact of the LBR on profitability is short-lived and disappears four years following the liquidity regulation change.

Our baseline results are not sensitive to variations in: the matching procedure used; the number of countries used to match treated and control banks; the covariates used in the propensity score matching; or the number of matched banks included in the sample. The robustness of our findings is also confirmed via a placebo test, which assumes falsely that the

LBR was introduced in an earlier time period. If banks anticipated the introduction of the LBR, we would expect a change in bank risk during this period. The results of this placebo test do not show any evidence of anticipatory effects via changes in bank risk. We also test for a potential regression to the mean (RTM) bias due to the matching by re-estimating our baseline model using an unmatched sample. The results indicate that our matching does not lead to an RTM bias.

Our study contributes to the recent literature on the impact of liquidity regulations on bank behavior. The salient literature examining liquidity regulation has focused on examining banks' contribution to real economic activity (De Nicolo et al., 2014; Covas and Driscoll, 2014; Duijm and Wierts, 2016; Banerjee and Mio, 2018; Reinhardt et al., 2020; Ananou et al., 2021). In general, this literature identifies several ways banks can use to comply with liquidity requirements, which ultimately affects their risk-taking behavior. For example, Duijm and Wierts (2016) and Banerjee and Mio (2018) show that the introduction of liquidity regulation requires banks to adjust balance sheet composition by increasing the share of high-quality liquid assets and reducing reliance on short-term wholesale funding. In the case of the Netherlands, prior evidence indicates that the introduction of the LBR led affected banks to change the volume and composition of lending. Specifically, the enactment of the LBR led to: an increase in the overall volume of lending; a re-orientation toward corporate lending; and an increase in deposit and equity funding (Ananou et al., 2021). A decline in inter-bank lending is also evident (Bonner and Eijffinger, 2016). With regard to the impact of liquidity regulation on bank risk-taking, Bosshardt et al. (2021) introduce a theoretical model to assess how much risk banks are encouraged to take with illiquid assets, in order to comply with liquidity requirements (similar to the LCR). The model shows that in reaction to more onerous liquidity requirements, banks with a significant proportion of stable liabilities select riskier long-term investments to maintain profitability. In comparison, banks with a smaller share of stable liabilities invest in safe assets, given that these can be liquidated at low cost in the event of distress. Complementing this literature, the difference-in-differences approach used in the current paper allows us to identify the causal impact of liquidity requirements on the risk and pricing of assets and liabilities of banks subject to the provisions of the LBR.

Our findings also contribute to research that explores the determinants of bank risk. Prior evidence suggests that macroeconomic conditions (Athanasoglou et al., 2008; Albertazzi and Gambacorta, 2009), competition (Beck et al., 2013; Liu et al., 2013; Goetz, 2018), ownership

(Iannotta et al., 2007; Barry et al., 2011); size (De Haan and Poghosyand, 2012); funding structure (Demirguc-Kunt and Huizinga, 2010; Vazquez and Federico, 2015; Khan et al., 2017), capital (Berger, 1995; Giordana and Schumacher, 2017), diversification (Demsetz and Strahan, 1997; DeYoung and Roland, 2001; Lepetit et al., 2008), corporate governance (Berger et al., 2016; Anginer et al., 2018); loan growth (Foos et al., 2002) and business models pursued by banks (Altunbas et al., 2011; Kohler, 2015) impact risk.

Finally, we also contribute to the literature examining the importance of liquidity for bank stability. In a theoretical exposition, Wagner (2007) shows that an increase in liquidity reduces the likelihood of bank runs and thus leads banks to increase risk-taking. Kohler (2015) finds that retail-oriented banks become riskier as their share of non-deposit to total funding increases. Chiaramonte and Casu (2017) find that banks with higher structural liquidity, as measured by the NFSR, are less likely to default. However, they also find that the LCR is not related to bank default risk. We augment this literature by documenting that a change in asset liquidity requirements induces a long-lasting decline in bank risk.

The remainder of the paper is organized as follows. Section 2 describes the empirical methodology and presents the data and summary statistics of the sample. In Section 3, we present the results of our empirical analysis. Section 4 provides additional evidence to support our main results. Sensitivity checks are reported in Section 5. Section 6 concludes.

2. Research design

2.1 Data and sample

Our sample period spans 1998-2008 and straddles the introduction of the LBR in 2003. [4] We use a sample of commercial banks from 12 European countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain) forming the Eurozone in 2003. We collect bank accounting data from the BankScope database compiled by Bureau van Dijk. All the banks in our sample report annual financial statements with the fiscal year ending December 31. For each bank, we use unconsolidated data if available. Otherwise, we use consolidated statements. We identify commercial banks with at least three consecutive years of observations for net income, total equity, and total assets. This allows us to compute the rolling-window standard deviations required to construct our risk

[4] The main analysis is carried out on the period 2000-2006. The longer sample period enables us to investigate the long-term impacts of the LBR on various bank outcome variables (in section 4 of the paper).

indicators. To minimize the effect of outliers, we eliminate extreme observations (5% lowest and highest values) for each variable of interest. In order to reduce the possible impact of mergers and acquisitions that took place during the sample period, we also discard all bank-year observations where growth in total assets exceeds 25%. Our final sample, prior to matching, comprises 400 commercial banks, including 16 Dutch banks.

In our analysis, we also construct a subsample dataset of listed banks. We retrieve daily market data from the Bloomberg database. The subsample is restricted to banks with continuously daily traded stocks between January 1, 1998, and December 31, 2008. We obtain, before matching, a final subsample of 117 listed banks. Columns (1) and (3) of Table 1 present information on the geographic distribution of the initial sample of banks.

[Insert Table 1 here]

2.2 Methodology

The research design employed in this study allows us to identify the causal impact of liquidity regulation on bank risk. To that end, we rely on the introduction of the LBR in the Netherlands in 2003, which provides exogenous variation in the liquid assets held by Dutch banks.[5] The regulation was announced in January 2003, and Dutch banks had until July 2003 to comply with the requirements (de Haan and den End, 2013), thus minimizing the possibility of anticipatory effects and subsequent changes in bank behavior prior to implementation. Given that 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). Moreover, other regulatory events that may have occurred at the regional or international level when the LBR was announced and implemented (such as the publication of the preliminary draft of the Basel II requirements) would affect banks in the Eurozone the same way. Hence, the introduction of the LBR can be considered as an exogenous change in the liquid assets held by Dutch banks.

The LBR stipulates that Dutch banks should hold high-quality liquid assets greater than or equal to net cash outflows over a 30-day stress period. The LBR is defined as LBR=AL/RL,

[5] 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.

where: AL denotes Actual Liquidity which comprises the weighted sum of the stock of liquid assets and cash inflow scheduled within the next 30 days such as securities, inter-bank assets payable on demand and debts immediately due or payable by public authorities and professional money-market participants; and RL denotes Required Liquidity which comprises the weighted sum of the stock of liquid liabilities and cash outflow scheduled within the next 30 days such as any bank debt that can be called upon immediately (e.g., deposits without a fixed maturity). In order to comply with the regulation, the ratio of a given bank should be at least equal to one. Each item included in AL and RL carries an associated weight to reflect the degree of illiquidity and account for market and funding liquidity risks. These weights are determined by the regulator (DNB, 2011). For example, asset-backed securities carry a lower weight than high-quality bonds. Wholesale deposits carry a higher weight than retail deposits.

Our analysis is based on propensity score matching combined with a difference-in-differences estimation, which compares the change in risk of Dutch banks between the pre-LBR and post LBR period, with the change in risk of a similar group of European banks for which the LBR did not apply. The baseline model is as follows:

$$Y_{i,t} = \beta_1(Affected_i \times PostEvent_t) + \delta X_{i,t-1} + \alpha_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

*w*here *i* indexes bank and *t* indexes time. $Y_{i,t}$ denotes accounting-based or market-based bank risk measures. $Affected_i$ is a dummy variable equal to one for banks subject to the LBR (Dutch banks) and zero otherwise. $PostEvent_t$ is a dummy variable for the treatment period, equal to one for the years 2003 to 2006, and zero for the years 2000 to 2002. $X_{i,t-1}$ represents a vector of bank-level and country-level control variables that prior literature considers as important determinants of bank risk. To avoid simultaneity, we lag each of our control variables by one period. 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.

2.3 Measures of bank risk-taking and default risk

To measure bank risk-taking, we use the standard deviation of the return on assets (SDROA) computed on a rolling window basis of three years. We also consider the Z-Score as a proxy for bank default risk. We follow established practice and construct a variable named ZSCORE:

$$\text{ZSCORE} = \frac{\text{MROA} + \text{EQUITY}}{\text{SDROA}}$$

where MROA is the three-year rolling window average return on assets, defined as the ratio of net income to total assets, and EQUITY is the ratio of total equity to total assets (Boyd and Graham, 1986; Berger et al., 2004; Laeven and Levine, 2009; Anginer et al., 2012; Beck et al., 2013; Fang et al., 2013; Allen and Gale, 2014; Ashraf, 2017).

We follow Goyeau and Tarazi (1992) and Lepetit et al. (2008) and decompose the ZSCORE into its constituent components, Z1 and Z2.[6] Z1 measures asset risk, while Z2 is a measure of leverage risk. These two measures allow us to capture whether a change in ZSCORE is driven by a change in asset and/or leverage risk. For robustness, we also consider SDROA using a four-year rolling window and a five-year rolling window. ZSCORE is then computed with these alternative definitions of SDROA.

Given that accounting-based variables may not accurately capture sudden changes in bank risk, we complement these measures with market-based indicators for a sub-sample of listed banks. Risk is measured using the standard deviation of bank daily stock returns within a calendar year (SDR).[7] To assess default risk, we calculate a market-based Z-Score (MZ) defined as:

$$\text{MZ} = (1+\bar{R})/\text{SDR}$$

where $\bar{R}$ is the average of bank daily stock returns within a calendar year. We also consider systematic risk as measured by BETA and the bank-specific risk (IVOL). BETA and IVOL are obtained by estimating the market model, for each year:

$$R_{i,t} = a_i + \beta_i R_{m,t} + \varepsilon_{i,t} \quad (2)$$

where $R_{i,t}$ is bank *i*'s daily stock return, and $R_{m,t}$ is the daily return of a market portfolio *m*. We use the Euro Stoxx Bank Index rate as a proxy for the market portfolio. BETA takes the value of the estimated coefficient β_i and IVOL is calculated as the standard deviation of the residuals derived from estimating Equation (2). For robustness and to ensure that our results are not driven by seasonality, we also compute SDR, MZ, BETA and IVOL using daily bank stock returns over the last three months of each year from 2000 to 2006 (Keloharju et al., 2016).

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[6] ZSCORE = Z1SCORE + Z2 = MROA/SDROA + EQUITY/SDROA

[7] Bank daily stock return ($R_{i,t}$) is computed as the logarithm of the ratio of two adjacent daily stock prices (i.e., $\ln(\text{Price}_t/\text{Price}_{t-1})$)

2.4 Individual Bank Control variables

All regressions include a set of control variables, which are expected to affect bank risk. These comprise the natural logarithm of total assets (SIZE) and the ratio of equity to total assets (EQUITY) to account for bank size and capitalization. Larger banks have a greater ability to diversify activities in order to reduce risk (Demsetz and Strahan, 1997). However, because of too-big-to-fail incentives, these banks may assume additional risk (Galloway et al., 1997). The effect of bank capitalization on default risk is expected to be negative. However, its effect on risk-taking is not clear. Banks with higher capital ratios (on a market-value basis) are safer and take less risk due to the moderating effect of charter values (Keeley, 1990). However, more stringent capital regulation can encourage banks to take on more risk in order to maintain expected returns to shareholders (Koehn and Santomero, 1980; Kim and Santomero, 1988).

Bank funding is captured by the ratio of deposits to total assets (DEPOSITS). Banks with higher deposits-to-assets ratio are expected to be riskier. Prior evidence suggests that when deposits are insured, depositors lack the incentives to monitor activities, thus encouraging banks to take excessive risk (Demirguc-Kunt and Detragiache, 2002; Demirguc-Kunt and Kane, 2002; Barth et al., 2004). We also include the ratio of loans to total assets (LOANS). We expect a negative relationship between the loan to total assets ratio and risk given that loans are normally more stable than non-traditional intermediation activities (Iannotta et al., 2007). Lending is part of banks' traditional activities. Alternatively, loans can be riskier than other assets. Thus, the impact of LOANS on risk can be positive.

To control for differences in bank business models, we include the ratio of net non-interest income to net operating income (NNI). A greater reliance on non-interest income activities is found to be associated with higher risk (Stiroh, 2004; Lepetit et al., 2008, Demirgüc-Kunt and Huizinga, 2010; Altunbas et al. 2011). Liikanen (2012) indicates that income from non-interest activities is more volatile and can negatively affect the stability of a bank.

To account for operational efficiency, we consider the cost to income ratio (COSTINCOME), which should have a positive effect on risk. Under the so-called bad management hypothesis, banks operating at low levels of efficiency have higher costs due to inadequate credit monitoring and inefficient control of operating expenses which is reflected in lower cost efficiency (Berger and DeYoung, 1997). Declines in cost and revenue efficiency will temporally precede increases in risk due to credit, operational, market and reputational problems. This is corroborated by prior empirical evidence (Shehzad et al., 2010; Barry et al., 2011; Saramiento and Galan, 2017).

The list of all the variables used in the empirical analysis is presented in Table 2. 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 is not a concern.

[Insert Table 2 here]

[Insert Table 3 here]

2.5 The matching

Key to our identification strategy is the assumption that, in the absence of treatment, the coefficient of interest β_1 in Equation (1) is zero. This is also known as the parallel trend assumption. To alleviate concerns that the parallel trend assumption is violated, we use a propensity score matching procedure to construct a control group of European banks such that treated and control banks share similar trends in terms of risk (Roberts and Whited, 2013; Schepens, 2016). Therefore, following Daw and Hartfield (2018), we compute propensity scores based upon trends in the ZSCORE over the pre-treatment period for the full sample (and the MZ for the subsample of listed banks) and other balance sheet characteristics as well as national economic conditions in the pre-treatment period i.e. prior to the introduction of the LBR.[8] Specifically, the propensity scores are computed using: the growth rate in ZSCORE (MZ); ratio of total deposits to total assets; ratio of total equity to total assets; ratio of liquid assets to total assets; return on assets; real GDP growth; inflation; total assets; and lagged ZSCORE (MZ). Overall, we select banks of similar size, portfolio composition, capital structure, income, which operate under similar economic conditions in the pre-treatment period. The propensity scores are used to match each Dutch bank with its three nearest neighbors for the full sample and five nearest neighbors for the subsample of listed banks.[9] The propensity score matching is executed with replacement. This means that each non-Dutch bank can serve as a control for multiple Dutch banks. This improves the accuracy of the matching procedure (Smith and Todd,

[8] We consider trends in ZSCORE (MZ) because all the risk measures are highly correlated, as shown in Table 3. Consequently, we are confident that the other measures of risk employed in our analysis follow a similar trend. For robustness (section 5), we use trends in SDROA and SDR to run our matching process. Our findings remain the same when using these measures.

[9] We consider five neighbors for the listed banks to gain sufficient observations necessary to compute statistical tests.

2005). The propensity score matching also ensures that the coefficient of interest, β_1, captures the effect of the LBR on bank risk rather than by an artefact of sample selection where different trends in observables are exhibited by banks located in different countries.

The matching procedure yields a control group that comprises 42 banks drawn from other Eurozone countries for the broad sample of banks. For the subsample of listed banks, we end up with a control group that comprises 13 banks drawn from other Eurozone countries. Columns (2) and (4) of table 2 present the distribution of banks in the control group by country. The impact of the matching procedure is illustrated in Table 4. The table provides summary statistics for the main variables of interest for the three years prior to the introduction of the LBR and the three years after the introduction. The table also reports the mean differences test between Dutch and the broader sample of eurozone banks from which the control group of banks are selected.

The summary statistics show that the parallel trend assumption is violated when using the entire sample of non-Dutch banks as control group. Banks operating in the Netherlands differ in various characteristics compared to other European banks. For example, Dutch banks are on average larger and have significantly higher default risk during the pre-treatment period. The success of the matching is illustrated in the last three columns of the table, which shows that the difference in means between Dutch banks and the matched group of banks is not statistically significant for all bank characteristics. Moreover, the growth rates of bank risk measures are similar for banks in both groups.

[Insert Table 4 here]

Figure 1 depicts the evolution of the bank risk measures considered in our analysis over the period 2000 to 2006. The trends in all outcome variables follow similar paths in the pre-treatment period, supporting the notion that the parallel trends assumption is valid in our setting. However, from 2003, we observed diverging trends for the affected and control banks. This suggests evidence that the introduction of the LBR had an impact on the risk of Dutch banks.

[Insert Figure 1 here]

We further test for the parallel trend assumption by performing a placebo test. To investigate the effect of a placebo treatment, we assume that the LBR was introduced in 2001, rather than in 2003. We then re-run the matching process. The results are presented in row (1) of Table 11 and suggest that the parallel trend assumption is not violated and thus our identification strategy is valid.

3. Results

Baseline Results

In this section, we discuss the results of our regression analysis, which assesses the possible impact of the introduction of the LBR on bank risk. Table 5 presents the results of estimating equation (1). We follow the recent literature analyzing bank-risk measures such as the Z-Score or the standard deviation of returns and apply a log transformation to all the outcome variables.[10] The estimated models include bank-specific control variables to capture any potential shocks in one of the time-varying determinants of bank risk. We also include year fixed effects to capture effects common to all banks and bank fixed effects to account for any unobservable time-invariant bank characteristics.

[Insert Table 5 here]

In all regressions, using either accounting or market-based risk measures as outcome variables, β_1, the coefficient of interest, is negative and significant for SDROA, SDR, and positive and significant for ZSCORE, Z2 and MZ. This implies that following the introduction of the LBR, Dutch banks' risk declined, leading to a lower probability of default, as captured by the Z-score measures, relative to counterparts not subject to the LBR. For instance, the standard deviation of the return on assets of the average Dutch bank is reduced by 45% relative to an average bank not subject to the LBR. The ZSCORE increased by 51% for the average Dutch bank relative to the average non-Dutch bank not subject to the LBR. These changes in risk occur via a reduction in leverage. Specifically, we observe a positive impact of the introduction of the LBR on Z2. The impact on Z1 is not significant. Our results also suggest that, on average, the specific risk of Dutch banks decreases relative to controls not subject to the provisions of the LBR. This is in line with the view that the introduction of liquidity requirements leads to a decline in both bank risk and the probability of depositor runs (Diamond and Kashyap, 2016; Hoereva et al., 2018).

Turning to our control variables, we focus our discussion on the specification with

[10] Lepetit and Strobel (2015) indicate that log-transformed Z-scores may be more appropriate in applied work due to the skewness of Z-scores in levels. They add that the log of the Z-score can additionally be shown to be negatively proportional to the log odds of insolvency, giving it a sound probabilistic foundation. For comparability, we harmonize all the variables by applying a log transformation.

ZSCORE as an outcome variable (column 1 in Table 5). SIZE enters the regression with a positive coefficient, which is statistically significant at the 1% level. This indicates that a one percent increase in SIZE is associated with a 0.7 percent increase in ZSCORE. This is line with the view that larger banks have greater ability to diversify activities and reduce risk (Demsetz and Strahan, 1997). As expected, we also find that better capitalized banks (EQUITY) are associated with lower default risk. Interestingly, when the outcome variable is SDROA (column 4), better-capitalized banks assume higher asset risk. This is consistent with the view that more capital allows banks to fund riskier projects without jeopardizing solvency. DEPOSITS and COSTINCOME enter the regression with positive, but insignificant coefficients, while LOAN and NNI enter the regression with a negative, but insignificant coefficient. These variables are also insignificant in other regressions using different outcome variables. Finally, GROWTH enters the regression with a negative, but marginally significant coefficient, while the coefficient on INFLATION is negative and statistically insignificant. GROWTH is only significant in column 4, where the outcome variable is SDROA. Our results show that banks tend to increase the risk of asset portfolios during periods of buoyant economic conditions. This is consistent with the findings of previous studies (Bohachova, 2008; Altunbas et al., 2010; Maddaloni and Peydro, 2010; Haq and Heaney, 2012).

Overall, our results indicate that the introduction of the LBR reduces both the risk-taking and default risk of banks. However, an important issue is whether such an impact is transitory or long-lived. Indeed, to comply with the LBR, banks often need to make quick adjustments to balance sheets by increasing the share of liquid assets on the asset side of the balance sheet or reducing the share of non-stable funding in liabilities. However, once adjusted to new requirements, banks can react by increasing the risk of non-liquid assets in order to maintain profitability.

Impulse Response Functions

We investigate the dynamic impacts of liquidity regulation on bank risk and profitability (Jorda, 2005; Favara and Imbs, 2015). Specifically, we utilize impulse response functions for our outcome variable over different horizons. The impulse response functions correspond to a sequence of estimates β_1^j obtained from the estimations of:

$$\mathrm{Y}_{\mathrm{I,t+j}} = \beta_1^{\mathrm{j}}(\mathrm{Affected_i} \times \mathrm{PostEvent_t}) + \delta X_{i,t-1} + \alpha_\mathrm{i} + \lambda_\mathrm{t} + \varepsilon_{i,t} \quad (3)$$

where each β_1^j captures the effect of the introduction of the LBR at horizon *j*, with *j*=1, …, 5. Figure 2 plots the impulse response functions. For both the ZSCORE and SDR, the impulse response function shows a significant, albeit diminishing impact until the fifth year. This suggests that the introduction of the LBR has both an immediate and medium-term impact on bank risk.

[Insert Figure 2 here]

Relative Impact of LBR within the Treated Group of Dutch Banks

Given the heterogeneity in balance sheet structures and liquid asset holdings, the introduction of the LBR did not affect all Dutch banks equally. Consequently, as a further test, we assess whether the effect of the LBR on bank risk was similar for Dutch banks significantly affected by the enactment of the LBR and those that were not. Hoereva et al. (2018) stress that implementing liquidity requirements could incentivize highly liquid banks to invest in riskier assets. An increase in risk for highly liquid banks in our sample would suggest that the LBR encourages banks to take more risk. Conversely, a decrease in risk for banks already compliant with the new rule would indicate that the LBR imposed additional costs on all banks. Alternatively, highly liquid banks could be less affected than less liquid counterparts that are more constrained by the new rule, suggesting that the rule imposed costs only where required. To investigate this issue, we split the sample of Dutch banks into two subsamples based on the reported liquidity in 2002, the year prior to the introduction of the LBR. We measure liquidity by the ratio of liquid assets to total assets and the ratio of liquid assets to total deposits and short-term funding.[11] We split the sample using the median value and the third quartile of these aforementioned liquidity measures. We then use the matching procedure as described in section 2.5 to build a control group for each sub-sample comprising banks from other European countries.

[Insert Table 6 here]

The results, using the ratio of liquid assets and the ratio of liquid assets to total deposits and short-term funding as bank liquidity measures, are presented in Table 6 and Table 7, respectively. The coefficient of the interaction term (*Affected*$_i$ *x PostEvent*$_t$) is positively and statistically significant for the subsample of Dutch banks with relatively low liquidity. However,

[11] Figure 3 shows the distribution of the liquidity variables for Dutch banks in 2002.

the coefficient associated with the interaction term is not significant for the subsample of relatively highly liquid Dutch banks. The results remain identical when we further split the sample using third quartile values of liquidity in 2002.[12] These findings suggest that the introduction of the LBR did not encourage highly liquid banks to assume more risk or less risk. Only banks with relatively low liquidity were affected by the rule. Consequently, the LBR was efficient in achieving the regulatory objective of reducing bank risk-taking, while also improving liquidity.

[Insert Table 7 here]

Overall, we find that following the introduction of the LBR, less liquid banks became less risky relative to unaffected counterparts. The observed impact is both statistically and economically significant. On average, the ZSCORE increased by approximately 51%, while SDROA decreased by around 45%, compared to counterparts not subject to the LBR. As such, it appears that the introduction of the LBR leads banks to take lower risk and become less vulnerable to default.

4. Impacts of the LBR on profitability, income, cost and structure of funding

In this section, we examine the impact of the LBR on profitability and the structure and cost of bank funding. Hoereva et al. (2018) argue that liquidity constrained banks face a tradeoff between risk and profitability. A decrease in bank risk should be accompanied by a decline in profitability, given that the return on liquid assets is likely to be lower than the return on illiquid assets. The authors argue that funding costs matter for profitability and risk, particularly when banks are subject to liquidity regulation. They explain that when the return on liquid assets is lower than the cost of funding, banks may have incentives to invest in riskier assets in order to offset the negative impact on profitability. Banks can also adjust to the loss in income (driven by the constraint of holding larger shares of liquid assets) by increasing lending rates, albeit the viability of such a strategy depends on prevailing loan market competition. Giordana et al. (2017) contend that the impact of an increase in liquid assets on profitability is crucially dependent upon the structure of bank liabilities. Our results indicate that following the implementation of the LBR, Dutch banks became less vulnerable to default. A priori, we also

[12] To test for robustness, we include the subsample of Dutch highly liquid banks in the control group before the matching when analysing the subsample of low liquid banks. The results remain.

expect to observe a negative or insignificant impact of the introduction of the LBR on profitability, but a significant effect on the cost and structure of funding. To investigate these issues, we consider a Difference in Differences model as follows:

$$Y_{i,t} = \beta_1(\text{Affected}_i \times \text{PostEvent}_t) + \alpha_i + \lambda_t + \varepsilon_{i,t} \quad (4)$$

where: $Y_{I,t}$ denotes the outcome variable(s) of interest (profitability, cost of funding or funding structure); *i* indexes bank and *t* indexes time. *Affected$_i$* is a dummy variable equal to one for banks affected by the LBR (Dutch banks) and zero otherwise. *PostEvent$_t$* is a dummy variable for the treatment period and takes the value of 1 for the years 2003-2006, and zero for years 2000-2002. β_1 is the coefficient of interest, which represents the impact of the LBR on the outcome variable in question. The model also includes bank-specific fixed effects, α_i, to control for unobserved bank heterogeneity and year dummies λ_t, to capture time effects common to all banks. In the remainder of this section, we consider the impact of LBR on bank profitability, interest and non-interest income (section 4.1), cost of funding and loan pricing (section 4.2), and funding structure (section 4.3).

4.1 Bank profitability, interest, and non-interest income

To assess the impact of the introduction of the LBR on bank profitability, interest income and non-interest income, we estimate Equation (4) using: the return on assets (ROA); the ratio of total interest income to total assets (IINC); and the ratio of non-interest income to total assets (NII), as outcome variables. We further investigate the structure of bank revenue by analyzing the impact of the introduction of the LBR on the components of non-interest income. Specifically, we replace the outcome variable in Equation (4) with: the ratio of net gain/loss from trading activities to total non-interest income (TRADEGAIN); the ratio of net fees and commissions to total non-interest income (COM); and the ratio of other non-interest income to total non-interest income (EXTRA). The results of these estimations are presented in Table 8. As expected, the LBR has a negative and significant impact on bank profitability. This is driven by a reduction in interest income. However, the effect is not permanent. The last row of Figure 2 shows the impulse response function of ROA following the introduction of the LBR. The evolution of the impulse response function shows that four years following the introduction of the LBR, the effect on ROA becomes insignificant. A closer inspection of the evolution of non-interest income (in Table 8) reveals a heterogenous impact of the LBR. Specifically, following the introduction of the LBR, the income generated by trading activities declines, other non-interest income increases, and income from fees and commissions remains unchanged. This suggests that following the introduction of the LBR, Dutch banks shifted from trading activities to other non-interest generating activities.

[Insert Table 8 here]

Overall, the results suggest that the introduction of the LBR reduces profitability because it constrains banks to hold a larger share of less profitable liquid assets. An alternative explanation could be that banks face higher funding costs because they shift towards riskier assets in reaction to the introduction of the regulatory constraint. If depositors and other types of debt holders discipline banks effectively, then the required rate of return on bank liabilities would increase. Banks could also adjust to the new regulatory environment by increasing the interest rate charged on illiquid assets. This could have a detrimental impact and lead to credit rationing via the crowding out of safe borrowers (Stiglitz and Weiss, 1981). We investigate this issue in section 4.2.

4.2 Cost of funding and loan pricing

To investigate the impact of the LBR on bank funding costs and loan pricing, we consider the net interest margin (NIM) as an outcome variable and re-estimate Equation (4). NIM is calculated as the difference between the implicit interest rate on assets (INT), measured by the ratio of total interest income to total earning assets, and the implicit rate on liabilities (COST), measured by the ratio of total interest expenses to total liabilities. The results are presented in Table 9. We find that the coefficient of the interaction term ($Affected_i$ x $PostEvent_t$) enters the regression with a negative and statistically significant coefficient at the 5% level. The magnitude of the coefficient suggests that Dutch banks experience a decline in net interest margins (NIM) by 40 basis points on average following the enactment of the LBR. Further analysis of the components of NIM suggests that both the implicit interest rate charged by banks on their assets (INT) and that paid on their liabilities (COST) decreased following the introduction of the LBR. However, INT declines by more than COST, leading to the observed narrowing of NIM for Dutch banks.

Overall, it appears that relative to unaffected counterparts, Dutch banks did not attempt to offset any decline in profitability by increasing margins. Moreover, Dutch banks benefited from better financing conditions, which may have allowed them to increase the share of deposits and capital on the liability side of the balance sheet and offset any increases in insolvency risk stemming from a decline in profitability (Hartlage 2012).

[Insert Table 9 here]

4.3 Funding structure

To assess the impact of the LBR on bank funding structure, we use EQUITY and DEPOSITS as outcome variables and re-estimate Equation (4). The results of the estimation are presented in Table 10.

[Insert Table 10 here]

The results indicate that Dutch banks experienced an inflow of deposits and an increase in equity following the enactment of the LBR. A potential explanation is that Dutch banks may have increased equity in order to offset the increased insolvency risk arising from a decline in profitability. Prior evidence suggests that when bank profits decline as a result of an increase in liquid assets, insolvency risk also increases (Eisenbach et al., 2014; Konig, 2015). Therefore, by increasing capital, banks can offset any negative impact on risk.

5. Robustness and sensitivity analysis

In this section, we examine the robustness of our main results via a myriad of additional tests.

RTM bias

Daw and Hatfield (2018) argue that matching in difference-in-differences analyses can introduce regression to the mean (RTM) bias - a statistical phenomenon that can make a natural variation in repeated data look like real change. While the introduction of covariates (as performed in our analysis) helps mitigate this bias, Chabé-Ferret (2017) suggests testing the potential impact of the shock on the unmatched sample. Consequently, in order to alleviate concerns regarding whether the matching procedure adopted is forcing the parallel trend upon the sample, we re-estimate equation (1) on the unmatched sample of banks over the period 2000-2006. The results presented in row (2) of Table 11 suggest that the introduction of the LBR had a significant effect on Dutch bank risk-taking behavior relative to non-Dutch counterparts. These results confirm that the matching, which is conducted using trends in the outcome variables and covariates, has not generated a regression to the mean bias.

Measures of bank risk

In order to ensure that our results are not affected by the use of overlapping periods (rolling windows), we compute our accounting-based risk variables based on four-year and five-year rolling windows, instead of three-year rolling windows. For the subsample of listed banks, we consider the last three months of the year to compute the market-based risk indicators. We re-estimate equation (1) using these measures. The results of the estimations are presented in rows (4), (5) and (6) of Table 11. The results remain qualitatively similar to those reported in Table 5.

Matching procedures

We also assess whether variations in our matching procedure affect our results. First, we run the matching process using trends in SDROA and SDR rather than ZSCORE and MZ. The results of the estimation of Equation (1) using this alternative matching are presented in row (7) of Table 11. Our results continue to hold, and the magnitude of the coefficients are in line with our baseline results. We also vary the number of matched banks from three nearest neighbors to the nearest neighbor only, and then to the five nearest neighbors. Again, we obtain similar results (see rows 8 and 9).

The number of countries in the control group

Finally, we restrict the number of countries from which banks in the control group are selected. We use Belgium and Luxembourg for the control group, given that along with the Netherlands these countries are part of the historical Benelux economic union. An analysis based on these three countries is likely to address any omitted variable bias. However, given the specific nature of the banking system in Luxembourg (which specializes in wealth management), we conduct a further robustness check using Belgian banks only as our control group. The results remain qualitatively unchanged (see rows 10 and 11).

Parallel trend and placebo test

Finally, we test for the parallel trend assumption by performing a placebo test. In order to investigate the effect of a placebo treatment, we assume that the LBR was introduced in 2001, rather than in 2003. We then re-run the matching using the growth rate of ZSCORE and MZ. The results of our estimations, which are presented in row (9) of Table 11 suggest that the parallel trend assumption is not violated, and thus the identification strategy is valid.

[Insert Table 11 here]

6. Conclusion

Bank liquidity mismatches and shortages have been discussed extensively since the onset of the global financial crisis. In order to reduce the potential risks arising from bank illiquidity, the Basel Committee on Banking Supervision (BCBS) revised the regulatory framework to strengthen the global financial system and to reduce future spillovers to the real economy (BCBS, 2011). Among other things, the BCBS' new regulatory framework (Basel III) proposes two liquidity requirements to increase the resilience of banks to liquidity risk. The first measure is the Liquidity Coverage Ratio (LCR), which requires financial institutions to hold enough liquid assets to withstand a 30-day stress period. The second measure, the Net Stable Funding Ratio (NSFR), aims to improve banks' longer-term, structural funding. Despite recent regulatory developments and the obvious importance of liquidity for individual banks, the financial system and the real economy, there is a paucity of evidence regarding the impacts of regulation on bank risk.

In this study, we go some way to addressing this evidence gap via an in-depth investigation of the impact of liquidity regulation on bank risk. As a setting, we use the Liquidity Balance Rule (which is similar to the recently introduced Basel III LCR ratio), which was introduced in the Netherlands in 2003. This rule required Dutch banks to hold high-quality liquid assets greater or equal to net cash outflows over a 30-day stress period. We conduct an extensive empirical analysis at the bank level, where we compare the risk of Dutch banks between the pre-LBR and post-LBR period with the same difference in the risk of a control group of banks from other Eurozone countries not subject to the provision of the LBR. Our results show that following the introduction of the LBR, Dutch banks became less risky, albeit at the expense of profitability. Reduced funding costs allowed Dutch banks to change funding structure by increasing capital and improving solvency, which improves their stability relative to an average Eurozone bank not subject to the LBR. With regard to profitability, Dutch banks experienced a reduction in the income generated by interest-bearing activities as opposed to non-interest income, relative to unaffected banks. Moreover, the income generated by trading activities declined, other non-interest income increased, and income from fees and commissions remained unchanged.

Overall, our results indicate that the introduction of liquidity regulation reduces bank risk and the likelihood of default. Our findings do not lend support to the view that the introduction of liquidity requirements could be counterproductive by encouraging banks to take on more risk. However, given that the introduction of the LBR leads to a decline in bank profitability, bank stability could be a concern. Going forward and based on insights generated from the present study, there is a need for further investigations to better understand the impacts of more recently introduced liquidity regulations such as the LCR on bank risk and performance.

References

Albertazzi, U., Gambacorta, L., 2009. Bank profitability and the business cycle. Journal of Financial Stability 5 (4): 393–409.

Allen, F., Gale, D., 2004. Competition and financial stability. Journal of Money, Credit, and Banking 36(3): 453-480.

Altunbas, Y., Manganelli, S., Marques-Ibanez, D., 2011. Bank risk during the financial crisis: Do business models matter? European Central Bank Working Paper Number 1394.

Ananou, F., Chronopoulos, D., Tarazi, A., Wilson, J.O.S., 2021. Liquidity regulation and bank Lending, Journal of Corporate Finance 69(1), article 101997.

Anginer, D., Demirguc-Kunt, A., Zhu, M., 2014. How does deposit insurance affect bank risk? Evidence from the recent crisis. Journal of Banking & Finance 48: 312-321.

Anginer, D., Demirguc-Kunt, A., Huizinga, H., Ma, K., 2018. Corporate governance of banks and financial stability. Journal of Financial Economics, 130(2):327-346.

Anginer, D., Bertay, C.A., Cull, R., Demirguc-Kunt, A., Mare, D.S., 2021. Bank capital regulation and risk after the Global Financial Crisis. Journal of Financial Stability, 130(2):327-346.

Athanasoglou, P., Brissimis, S.N., Delis, M., 2008. Bank-specific, industry-specific, and macroeconomic determinants of bank profitability. Journal of International Financial Markets, Institutions and Money, 18:121-136.

Ashraf, B.N., 2017. Political institutions and bank risk-taking behavior. Journal of Financial Stability 29: 13-35.

Banerjee, R. N., Mio, H., 2018. The Impact of liquidity regulation on banks. Journal of Financial Intermediation 35:30–44.

Barry, T.A., Lepetit, L., Tarazi, A., 2011. Ownership structure and risk in publicly held and privately owned banks. Journal of Banking & Finance 35 (5):1327–1340.

Basel Committee on Banking Supervision, 2009. International framework for liquidity risk measurement, standards, and monitoring. Basel: Bank of International Settlements.

Basel Committee on Banking Supervision (BCBS), 2011. Basel III: A global regulatory framework for more resilient banks and banking systems. Bank for International Settlements.

Basel Committee on Banking Supervision, 2013. Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools. Basel: Bank of International Settlements.

Beck, T., De Jonghe O., Schepens G., 2013. Bank competition and stability: Cross-country heterogeneity. Journal of Financial Intermediation 22:218-244.

Berger, A. N., 1995. The relationship between capital and earnings in banking. Journal of Money, Credit, and Banking 27 (2):432–456

Berger, A.N., Imbierowicz, B., Rauch, C., 2016. The roles of corporate governance in bank failures during the recent financial crisis. Journal of Money, Credit and Banking 48(4): 729-770.

Bohachova, O. 2008. The impact of macroeconomic factors on risks in the banking sector: a cross-country empirical assessment. IAW Discussion Paper Number 44.

Bonner, C., Eijffinger, S. C. W., 2016. The impact of liquidity regulation on bank intermediation. Review of Finance 20(5):1945–79.

Bonner, C., van Lelyveld, I., Zymek, R., 2015. Banks' liquidity buffers and the role of liquidity regulation. Journal of Financial Services Research 48(3): 215-234.

Bosshardt, J., Kakhbod, A. and Saidi, F., 2021. Liquidity Regulation and Bank Risk Taking on the Horizon. Available at SSRN: https://ssrn.com/abstract=3550912

Boyd, J.H., Graham, S.L., 1986. Risk, regulation, and bank holding company expansion into nonbanking. Federal Reserve Bank of Minneapolis Quarterly Review 10 (2): 2–17.

Chabé-Ferret, S., 2017. Should we combine difference in differences with conditioning on pre-treatment outcomes? Toulouse School of Economics Working Paper Number 17-824.

Chiaramonte, L., 2018. Bank liquidity and the global financial crisis. Basingstoke: Palgrave MacMillan.

Chiaramonte, L., Casu, B., 2017. Capital and liquidity ratios and financial distress: Evidence from the European banking industry. British Accounting Review 49(2):138–61.

Covas, F., Driscoll, J. C., 2014. Bank liquidity and capital regulation in general equilibrium. FEDS Working Paper Number 2014-85.

Daw, J. R., Hatfield, L. A., 2018. Matching and regression-to-the-mean in difference-in-differences analysis. Health Services Research, 53(6): 4138–4156.

DeYoung, R., Roland, K., 2001. Product mix and earnings volatility at commercial banks: evidence from a degree of total leverage model. Journal of Financial Intermediation 10: 54-84.

DeYoung, R., Jang, K. Y., 2016. Do banks actively manage their liquidity? Journal of Banking & Finance, 66, 143-161.

Duijm, P., Wierts, P., 2016. The Effects of liquidity liabilities regulation on bank assets and liabilities. International Journal of Central Banking 12(2):385–411.

DNB, 2011. Regulating Liquidity under Wft. Amsterdam: DNB.

Diamond, D.W., Kashyap, A., 2016. Liquidity requirements, liquidity choice, and financial stability, In: Taylor, J. B., Uhlig, H. (eds.) Handbook of Macroeconomics. Amsterdam: Elsevier.

De Haan, J., Poghosyand. T., 2012. Bank size, market concentration, and bank earnings volatility in the US. Journal of International Financial Institutions, Markets and Money 22 (1):35–54.

Demirguc-Kunt, A., Huizinga, H., 2010. Bank activity and funding strategies: The impact on risk and returns. Journal of Financial Economics 98(3):626-650.

Demsetz, R.S., Strahan, P.E., 1997. Diversification, size, and risk at bank holding companies. Journal of Money, Credit and Banking 29 (3): 300–313.

De Nicolò, G., Gamba, A., Lucchetta, M., 2014. Microprudential regulation in a dynamic model of banking. Review of Financial Studies 27(7):2097–2138.

Eisenbach, T. M., Keister, T., McAndrews, J. J., Yorulmazer, T., 2014. Stability of funding models: an analytical framework. FRBNY Economic Policy Review February: 29-47.

Fang, Y., Hasan, I., Marton, K., 2014. Institutional development and bank stability: Evidence from transition countries. Journal of Banking & Finance 39: 160-176.

Favara, G., Imbs, J., 2015. Credit supply and the price of housing. American Economic Review 105(3):958-92.

Fegatelli, P, 2010. The misconception of the option value of deposit insurance and the efficacy of non-risk-based capital requirements in the literature on bank capital regulation. Journal of Financial Stability 6(2): 79-84.

Giordana, G. A., Schumacher, I., 2017. An empirical study on the impact of Basel III standards on banks' default risk: The case of Luxembourg. Journal of Risk and Financial Management 10(2): 8-29.

Goetz, M. R., 2018. Competition and bank stability. Journal of Financial Intermediation, 35, 57-69.

Goyeau, D., Tarazi, A., 1992. Évaluation du risque de défaillance bancaire en Europe. Revue d'Économie Politique 102:249–280.

Gjerde, Ø., Semmen, K., 1995. Risk-based capital requirements and bank portfolio risk. Journal of Banking and Finance 19(7): 1159-1173.

Hartlage, A.W., 2012. The Basel III liquidity coverage ratio and financial stability. Michigan Law Review 111(3).

Haq, M., Heaney, R., 2012. Factors determining European bank risk. Journal of International Financial Markets, Institutions and Money 22(4): 696-718.

Hoerova, M., Mendicino, C., Nikolov, K., Schepens, G., Van den Heuvel, S., 2018. Benefits and costs of liquidity regulation. ECB Working Paper Series Number 2169.

Hong, H., Huang, J.-Z., Wu, D., 2014. The information content of Basel III liquidity risk measures. Journal of Financial Stability 15:91–111.

Iannotta, G., Nocera, G., Sironi, A., 2007. Ownership structure, risk, and performance in the European banking industry. Journal of Banking & Finance 31:2127–2149.

Jorda O., 2005. Estimation and inference of impulse response by local projection. American Economic Review 95 :161-182.

Keloharju, M., Linnainmaa, J.T., Nyberg, P., 2016. Return seasonalities. Journal of Finance 71(4), pp.1557-1590.

Khan, M. S., Scheule, H., Wu, E., 2017. Funding liquidity and bank risk taking. Journal of Banking & Finance 82:203-216.

Kim, D., Santomero, A., 1988. Risk in banking and capital regulation. Journal of Finance 43(5): 1219-1233

Koehn, M., Santomero, A., 1980. Regulation of bank capital and portfolio risk. Journal of Finance 35(5): 1235-1244.

Köhler, M., 2015. Which banks are more risky? The impact of business models on bank stability. Journal of Financial Stability 16: 195-212.

Konig, P. J., 2015. Liquidity requirements: A double-edged sword. International Journal of Central Banking 42:129-168.

Laeven, L., Levine, R., 2009. Bank governance, regulation, and risk-taking. Journal of Financial Economics, 93:259-275.

Lambert, C., Noth, F., Schuwer, U., 2017. How do insured deposits affect bank risk? Evidence from the 2008 Emergency Economic Stabilization Act. Journal of Financial Intermediation 29:81-102.

Lepetit, L., Nys, E., Rous, P., Tarazi, A., 2008. Bank income structure and risk: An empirical analysis of European banks. Journal of Banking & Finance 32: 1452–1467.

Liu, H., Molyneux, P., Wilson, J.O.S., 2013. Competition and stability in European Banking: A regional analysis *Manchester School*, 81: 176-201.

Maddaloni, A, Peydro, J.L., 2010. Bank Risk-taking, Securitization, Supervision, and Low Interest Rates: Evidence from the Euro-area and the U.S. Lending Standards. ECB Working Paper 1248.

Roberts, M. R., Whited, T. M., 2013. Endogeneity in empirical corporate finance. In Constantinides, G., Milton, H. and Stulz. R (eds.) Handbook of the Economics of Finance. Vol. 2 Amsterdam: Elsevier.

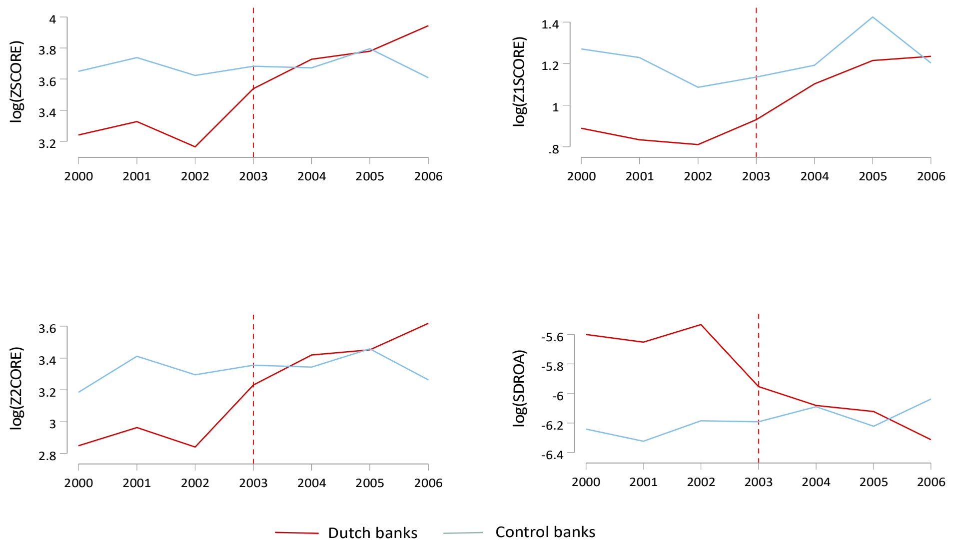
Schepens, G., 2016. Taxes and bank capital structure. Journal of Financial Economics 120(3): 585—600.

Smith, J. A., Todd, P. E., 2005. Does matching overcome LaLonde’s critique of non-experimental estimators? Journal of Econometrics 125(1–2):305–53.

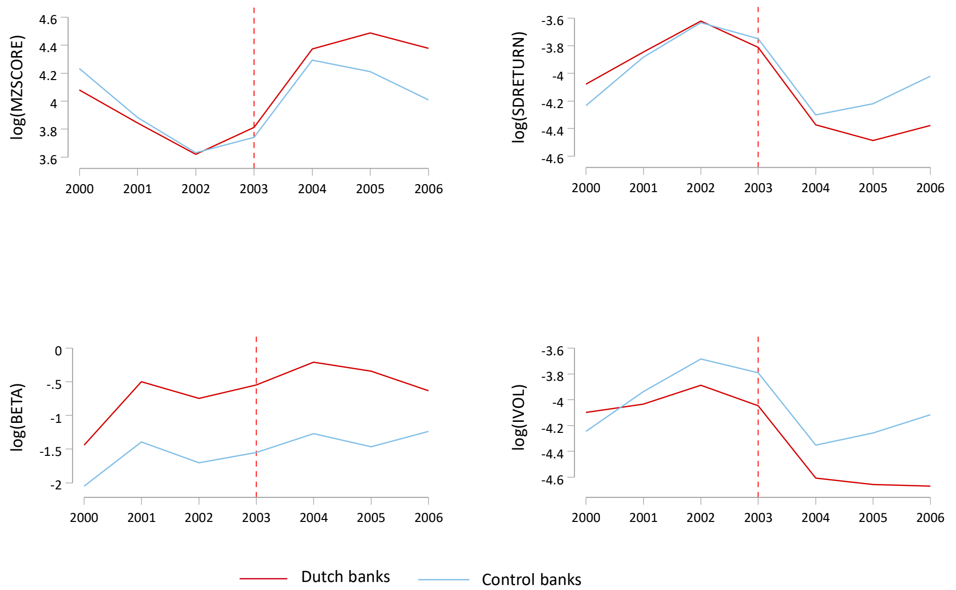
Wagner, W., 2007. The Liquidity of bank assets and banking stability. Journal of Banking & Finance, 31(1): 121-139.

Figure 1. Evolution of outcomes variable for Dutch banks and control banks

Panel 1. Broad sample of banks

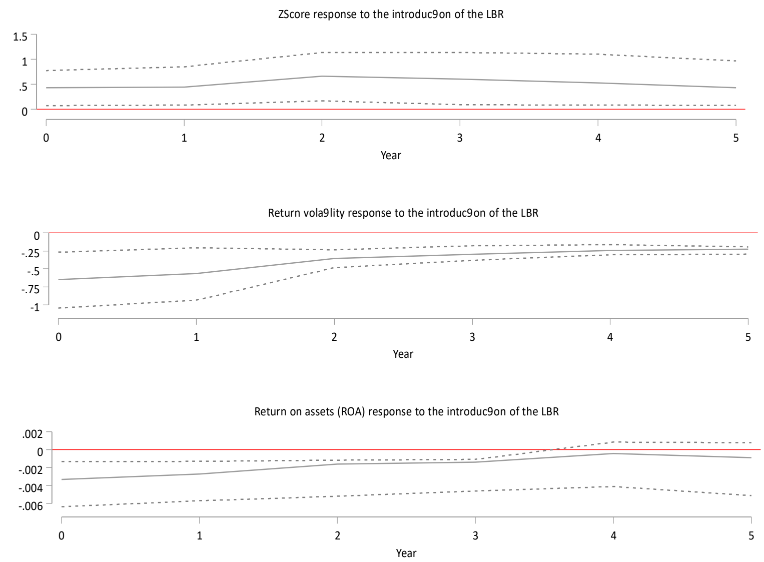


Panel 2. Subsample of listed banks.



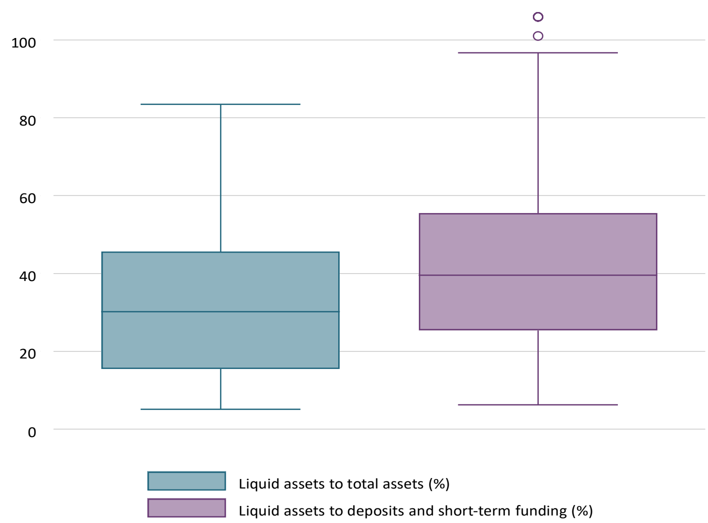
Note: This figure plots the evolution of the outcome variables for both treated and control banks over the period 2000-2006. The dashed vertical line in each graph marks 2003, the year LBR came into effect. Panel 1 depicts the mean of the logarithm of ZSCORE, Z1, Z2 and SDROA for the broad sample of banks. Panel 2 depicts the mean of MZ, SDR, BETA, IVOL for the subsample of listed banks. The control group includes all the banks selected via the nearest neighbor matching.

Figure 2. Impulse Response Functions: Bank risk and profitability



Notes: This figure plot the impulse responses of bank risk (ZSCORE and SDR) and profitability (ROA) to the introduction of the LBR. The IRFs are computed following the method proposed by Jorda (2005). Doted lines are the 95 percent confidence bands.

Figure 3. Distribution of liquid assets for Dutch banks



Notes: This figure plot the distribution of the ratio of liquid assets to total assets and the ratio of liquid assets to total deposits and short-term funding for Dutch banks in 2002.

Table 1. Distribution of commercial banks in the sample by Country

Country	Broad sample of banks		Subsample of listed banks	
	Full sample	Matched sample	Full sample	Matched sample
	(1)	(2)	(3)	(4)
Austria	38	5	8	0
Belgium	20	3	4	1
Finland	3	0	4	1
France	90	9	26	3
Germany	86	9	23	4
Greece	11	0	1	0
Ireland	5	1	0	0
Italy	20	1	10	1
Luxembourg	60	8	14	0
Netherlands	16	16	4	4
Portugal	11	3	7	1
Spain	40	3	16	2

Notes: This table indicates for each country, the number of commercial banks included in the full sample

Table 2. Variable definitions

Variable	Description	Source	Expected sign
Dependent variables			
BETA	Systematic risk computed by regressing bank daily stock return on a benchmark market excess return within a calendar year. BETA is the coefficient associated with the market excess return	Author computed	
IINC	Ratio of interest income to total assets (%)	Author computed	
INT	Ratio of total interest income on to total earning assets (%)	Author computed	
IVOL	Bank specific risk computed as the annualized standard deviation of the residuals of the regression of bank daily returns on a benchmark market excess return.	Author computed	
COST	Ratio of total interest expenses on to total liabilities (%)	Author computed	
MZ	Market based Z-Score defined as (100+$\bar{R}$)/SDR where $\bar{R}$ and SDR are expressed in percentages.	Author computed	
NII	Ratio of non-interest income to total assets (%)	Author computed	
NIM	Net interest margin defined as the difference between INT and COST	Author computed	
ROA	Return on assets defined as the ratio of net income to total assets (%)	Bankscope	
SDR	Market based bank risk defined as the geometric standard deviation of daily stock returns within a calendar year (%)	Author computed from Bloomberg	
SDROA	Three-year rolling window standard deviation of ROA (%)	Author computed	
ZSCORE	Bank default risk. ZSCORE = (MROA + EQUITY)/SDROA, where EQUITY is the ratio of total equity to total assets; and MROA is the three-year rolling window average of ROA	Author computed	
Z1	First component of ZSCORE. Z1 = MROA/SDROA	Author computed	
Z2	Second component of ZSCORE. Z2 = EQUITY/SDROA	Author computed	
Control variables			
COSTINCOME	Cost to income ratio (%)	Bankscope	-
DEPOSITS	Ratio of customer deposits to total assets (%)	Bankscope	+
EQUITY	Ratio of total equity to total assets (%)	Bankscope	+/-
GROWTH	Year-to-year growth rate of real GDP	Eurostat	+
INFLATION	Year-to-year growth rate of harmonized price index	Eurostat	-
LOANS	Ratio of net loans to total assets (%)	Bankscope	+/-
NNI	Ratio of net noninterest income to net operating income (%)	Bankscope	-
SIZE	Natural logarithm of total assets	Bankscope	+/-
LLR	Loan loss reserves (%)	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

Table 3. Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11
Panel 1. Broad sample of banks											
1. SDROA	1.00										
2. ZSCORE	-0.37	1.00									
3. Z1	-0.40	0.73	1.00								
4. Z2	-0.36	0.97	0.70	1.00							
5. NII	0.12	-0.17	-0.06	-0.17	1.00						
6. COSTINCOME	0.14	-0.11	-0.28	-0.10	0.17	1.00					
7. DEPOSITS	-0.03	-0.02	0.07	-0.02	0.08	0.20	1.00				
8. EQUITY	0.31	0.18	-0.05	0.19	-0.03	-0.14	-0.16	1.00			
9. SIZE	-0.23	-0.06	0.12	-0.07	-0.04	-0.11	-0.26	-0.42	1.00		
10. LOANS	-0.13	0.07	0.14	0.06	-0.35	0.06	0.18	-0.15	-0.02	1.00	
11. LLR	0.13	-0.11	-0.02	-0.11	-0.04	0.18	0.17	-0.07	-0.15	0.28	1.00
Panel 2. Subsample of listed banks											
1.SDR	1.00										
2. MZ	-0.35	1.00									
3. BETA	0.44	-0.18	1.00								
4. IVOL	0.99	-0.34	0.06	1.00							
5. NII	-0.01	0.02	0.08	-0.03	1.00						
6. COSTINCOME	0.22	-0.10	0.18	0.21	0.11	1.00					
7. DEPOSITS	0.13	-0.03	-0.14	0.16	0.09	0.11	1.00				
8. EQUITY	-0.11	0.09	-0.14	-0.08	-0.12	-0.19	-0.23	1.00			
9. SIZE	-0.01	-0.17	0.64	-0.12	-0.01	0.21	-0.27	-0.07	1.00		
10. LOANS	-0.04	0.10	-0.02	-0.03	-0.06	0.00	0.20	0.17	-0.20	1.00	
11. LLR	-0.02	0.05	-0.22	0.03	-0.09	-0.12	-0.04	0.15	-0.34	0.43	1.00

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

Table 4. Summary statistics

	Dutch banks		Full control group			Matched control group		
	Mean	Std. Dev.	Mean	Std. Dev.	Diff	Mean	Std. Dev.	Diff
Panel A: Pre LBR period								
SDR	1.970	1.105	1.841	1.546	0.129	2.182	0.861	-0.211
SDRGW	4.420	13.896	9.310	14.929	-4.890**	3.386	15.1910	0.034
MZ	50.219	4.621	91.679	6.554	-41.460***	54.091	4.195	-3.872
MZGW	-6.496	8.536	22.042	4.892	-28.539**	-6.155	6.184	0.058
BETA	0.562	0.596	0.196	0.335	0.365**	0.443	0.458	0.119
BETAGW	9.415	6.812	14.818	0.689	-4.613*	8.485	5.214	0.951
IVOL	1.600	0.738	1.757	1.516	-0.157	1.983	1.917	-0.383
IVOLGW	-5.365	11.077	8.224	4.946	-13.587***	-3.737	15.258	1.628
ROA	1.111	1.592	0.600	1.217	0.512**	0.842	1.501	0.271
SDROA	0.610	0.727	0.377	0.574	0.233**	0.453	0.674	0.156
SDROAGW	1.131	12.487	1.453	1.867	-0.231***	1.079	2.294	0.052
ZSCORE	49.796	9.349	76.265	13.543	-26.469***	66.887	6.458	-19.443*
ZSCOREGW	29.057	12.036	53.466	7.72	-24.409***	26.883	12.831	2.174
Z1	3.804	4.293	5.054	5.795	-1.249*	4.985	5.761	-1.182
Z1GW	-31.297	4.161	-24.241	5.639	17.11*	-27.347	8.740	3.819
Z2	46.105	8.854	71.126	2.541	-25.022***	64.180	6.791	-18.075*
Z2GW	31.293	12.113	54.386	7.759	-23.092**	34.332	5.791	3.038
NNI	27.782	16.799	37.649	23.420	-9.866***	24.744	24.109	2.600
COSTINCOME	53.401	18.444	62.532	22.166	-9.131***	51.726	24.152	1.680
DEPOSITS	48.647	28.726	51.370	24.879	-2.727	45.685	20.208	2.962
EQUITY	11.415	11.435	9.733	12.955	1.681	10.280	9.644	1.135
SIZE	8.115	1.776	7.403	1.991	0.711***	7.869	2.242	0.245
LOANS	46.579	24.552	46.602	27.689	-0.592	48.729	27.041	-2.718
LLR	0.631	0.489	1.999	2.302	-1.363***	0.863	2.061	-0.232
GROWTH	1.350	0.656	2.009	1.894	-0.659***	2.009	1.894	-0.659***
INFLATION	0.329	0.172	0.599	0.617	-0.269***	0.599	0.617	-0.269***
Panel B : Post LBR period								
SDR	0.923	0.588	1.209	1.830	-0.286	1.079	2.825	-0.157*
SDRGW	-11.237	10.562	15.692	15.891	-26.929**	15.612	6.726	-26.849**
MZ	83.851	5.282	129.318	12.775	-45.467***	74.275	6.883	10.611***
MZGW	31.508	20.718	12.761	3.776	18.474***	27.774	9.498	3.734**
BETA	0.534	0.566	0.231	0.389	0.303*	0.542	0.417	0.007
BETAGW	5.934	7.287	5.786	4.232	0.148	6.614	3.981	-1.281
IVOL	0.754	0.155	1.161	0.106	-0.407**	0.971	0.438	-0.216
IVOLGW	-13.687	9.228	14.632	15.899	-28.329**	17.638	6.401	-31.025**
ROA	0.857	1.625	0.742	1.211	0.146	1.034	0.701	-0.178*
SDROA	0.407	0.549	0.362	0.581	0.0004	0.517	0.768	0.111
SDROAGW	0.754	1.003	1.091	3.034	-0.347**	1.144	0.508	-1.096**
ZSCORE	67.871	8.932	79.054	2.680	-11.182	71.488	7.076	-3.292
ZSCOREGW	33.021	10.977	60.891	9.96	-27.872*	25.198	9.349	8.171***
Z1	4.486	3.414	5.342	5.661	-0.856	5.180	5.615	-0.694
Z1GW	38.348	56.930	49.882	26.874	-11.534	27.465	34.510	10.883
Z2	63.295	8.513	73.405	2.547	-10.110	66.233	6.696	-2.784**
Z2GW	32.043	10.852	58.563	9.353	-26.520*	24.125	23.805	8.918 **
NNI	26.904	18.875	39.828	23.494	-12.925***	39.207	25/841	-8.894*
COSTINCOME	52.348	16.445	59.879	21.944	-7.530***	57.743	24.205	-5.394**
DEPOSITS	52.468	28.410	52.448	25.142	0.020	45.584	20.917	6.883**

EQUITY	11.940	10.432	9.662	12.874	1.431	9.682	12.363	1.358
SIZE	8.425	1.849	7.653	2.020	0.772***	7.571	2.391	0.854**
LOANS	47.993	26.154	48.026	28.738	-0.908	50.421	28.271	-3.203
LLR	1.481	2.259	2.099	2.160	-0.617	1.261	1.286	0.221
GROWTH	1.521	0.555	1.996	1.894	-0.474***	1.996	1.894	-0.474***
INFLATION	0.566	0.852	0.598	0.606	-0.032	0.598	0.606	-0.032

Notes: This table reports summary statistics of the outcome variables and the control variables for Dutch banks and non-Dutch banks in the pre-treatment (Panel A) and post treatment (Panel B) periods. SDRGW, MZGW, BETAGW, IVOLGW, SDROAGW, ZSCOREGW, Z2GW and Z2GW respectively describe the growth rates of SDR, MZSCOORE, BETA, IVOL, SDROA, ZSCORE, Z1 and Z2. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively for the difference in means test (t-test) between Dutch and Eurozone banks.

Table 5. Impact of LBR on bank risk

Variables	Panel 1 : Broad sample of banks				Panel 2 : sub sample of listed banks			
	ZSCORE	Z1	Z2	SDROA	SDR	BETA	IVOL	MZ
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Affected x PostEvent	0.434***	0.380	0.430***	-0.579**	-0.329**	-0.881	-0.301**	0.329**
	(0.190)	(0.641)	(0.189)	(0.196)	(0.115)	(0.934)	(0.107)	(0.133)
DEPOSITS	0.001	0.031**	-0.001	0.007	-0.002	-0.012	-0.023	0.021**
	(0.005)	(0.013)	(0.005)	(0.007)	(0.008)	(0.021)	(0.076)	(0.008)
EQUITY	0.041**	-0.025**		0.017**	-0.019**	-0.004	-0.024**	0.019**
	(0.009)	(0.011)		(0.009)	(0.009)	(0.031)	(0.008)	(0.009)
SIZE	0.661***	0.316***	0.651***	-0.116***	-0.151**	0.021	-0.149***	0.151**
	(0.105)	(0.087)	(0.106)	(0.104)	(0.056)	(0.024)	(0.062)	(0.067)
LOANS	-0.005	-0.015**	-0.005	0.005	0.082	0.003**	0.083	-0.083
	(0.006)	(0.099)	(0.006)	(0.006)	(0.311)	(0.001)	(0.283)	(0.312)
NNI	-0.004	-0.001	0.004	-0.0001	0.001	-0.000	0.000	-0.001
	(0.005)	(0.006)	(0.005)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)
COSTINCOME	0.005	-0.035***	0.004	0.003	0.004	0.001**	0.003	-0.004
	(0.005)	(0.008)	(0.004)	(0.004)	(0.006)	(0.000)	(0.006)	(0.007)
LLR	-0.013**	-0.029**	-0.013**	-0.020	-0.151**	-0.328*	-0.150**	0.151**
	(0.007)	(0.094)	(0.007)	(0.228)	(0.067)	(0.201)	(0.052)	(0.057)
GROWTH	-0.043*	0.059*	-0.045	0.022**	-0.054**	-0.008	-0.052*	0.053**
	(0.027)	(0.036)	(0.053)	(0.004)	(0.019)	(0.071)	(0.043)	(0.020)
INFLATION	-0.055	0.012***	-0.052	-0.108	0.062	-0.033**	0.078**	-0.062
	(0.074)	(0.000)	(0.074)	(0.101)	(0.072)	(0.011)	(0.034)	(0.039)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	294	294	294	294	86	86	86	86
R-squared	0.974	0.826	0.973	0.904	0.978	0.903	0.982	0.978

Notes: The table analyses the impact of the introduction of the Liquidity Balance Rule in the Netherlands on bank risk in a difference-in-differences setup. The sample consists of banks from the Netherlands and the matched non-Dutch banks over the 2000-2006 period. In Panel 1, all the regressions are performed on a sample of 58 commercial banks. In Panel 2, all regressions are performed on a sample of 18 listed banks. ZSCORE is a measure of bank default risk, Z1 is a measure of bank asset risk; Z2 is a measure of bank leverage risk. SDR is the standard deviation of daily stock returns within a calendar year. BETA is a measure of systematic risk and IVOL is a measure of idiosyncratic risk. MZ is a market-based Z-Score defined as (100+RETURN)/SDR. All the dependent variables were log transformed. AFFECTED is a dummy is equal to 1 when the bank is a Dutch bank and 0 otherwise. POSTEVENT is a dummy equal to 1 for the years 2003 to 2006 and 0 otherwise. The model is estimated using OLS. The control variables comprise: SIZE defined as the natural logarithm of total assets, EQUITY defined as the ratio of total equity to total assets, DEPOSITS defined as the ratio of total customer deposits to total assets. LOANS is defined as of net loans to total assets. COSTINCOME is the ratio of operating expense over total operating income. LLR is the ratio of loan loss reserves to total assets, GROWTH is the real GDP growth and INFLATION is the inflation rate. The effect of LBR is captured by the coefficient on the interaction term Affected × Post Event. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Liquidity regulation and bank risk: disaggregation by banks' liquidity level using liquid assets to total assets

		ZSCORE	Z1	Z2	SDROA
(1)	Full sample	0.434***	0.380	0.430***	-0.579**
		(0.190)	(0.641)	(0.189)	(0.196)
(2)	Below the median	0.351***	0.331	0.345**	-0.516***
		(0.098)	(0.396)	(0.127)	(0.224)
(3)	Above the median	0.048*	-0.533	0.036*	-0.008**
		(0.029)	(0.696)	(0.017)	(0.007)
(4)	Below 3rd quartile	0.419***	0.370	0.415***	-0.627**
		(0.119)	(0.383)	(0.129)	(0.209)
(5)	Above 3rd quartile	-0.251	-0.534	-0.265	0.074
		(0.417)	(0.890)	(0.526)	(0.106)

Notes: Notes: The table analyses the impact of the introduction of the Liquidity Balance Rule in the Netherlands on bank risk in a difference-in-differences setup. Each row reports the estimates on a sub-sample consisting of banks from the Netherlands with a given level of liquidity and the matched non-Dutch banks over the 2000-2006 period. For brevity, we only report the estimated coefficients of the variable of interest Affected × Post Event. ZSCORE is a measure of bank default risk, Z1 is a measure of bank asset risk; Z2 is a measure of bank leverage risk. SDR is the standard deviation of daily stock returns within a calendar year. All the dependent variables were log transformed. Row (1) reports the estimate on the full sample. Row (2) presents the estimates when the treated group consists of Dutch banks with a ratio of liquid assets to total assets below the median and row (3) reports the opposite. Row (4) and (5) report respectively the estimates when the subsample consists of banks with a level of liquid assets to total assets below and above the 3r quartile respectively. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 7. Liquidity regulation and bank risk: disaggregation by banks' liquidity level using liquid assets to total deposits and short-term funding

		ZSCORE	Z1	Z2	SDROA
(1)	Full sample	0.434***	0.380	0.430***	-0.579**
		(0.190)	(0.641)	(0.189)	(0.196)
(2)	Below the median	0.375***	0.263	0.367**	-0.571**
		(0.153)	(0.267)	(0.148)	(0.251)
(3)	Above the median	0.482	-0.155	0.494	-0.453
		(0.434)	(0.475)	(0.459)	(0.498)
(4)	Below 3rd quartile	0.345***	0.364	0.344***	-0.541**
		(0.130)	(0.399)	(0.226)	(0.239)
(5)	Above 3rd quartile	0.117	-0.323	0.157	-0.335
		(0.536)	(0.628)	(0.547)	(0.537)

Notes: Notes: The table analyses the impact of the introduction of the Liquidity Balance Rule in the Netherlands on bank risk in a difference-in-differences setup. Each row reports the estimates on a sub-sample consisting of banks from the Netherlands with a given level of liquidity and the matched non-Dutch banks over the 2000-2006 period. For brevity, we only report the estimated coefficients of the variable of interest Affected × Post Event. Row (1) reports the estimate on the full sample. Row (2) presents the estimates when the treated group consists of Dutch banks with a ratio of liquid assets to total deposits and short-term funding below the median and row (3) reports the opposite. Row (4) and (5) report respectively the estimates when the subsample consists of banks with a level of liquid assets to total deposits and short-term funding below and above the 3r quartile respectively. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 8. Impact of LBR on bank profitability and income

Variables	ROA (1)	IINC (2)	NII (3)	TRADEGAIN (4)	COM (5)	EXTRA (6)
Affected x PostEvent	-0.004**	-0.019**	-0.006	-0.123**	0.823	0.076**
	(0.002)	(0.007)	(0.009)	(0.047)	(1.824)	(0.028)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	406	258	258	95	95	95
R-squared	0.769	0.908	0.744	0.515	0.942	0.896

Notes: The table analyses the impact of the introduction of the Liquidity Balance Rule in the Netherlands on bank profit, equity and deposits in a difference-in-differences setup. The sample consists of banks from the Netherlands and the matched non-Dutch banks over the 2000-2006 period. ROA is a measure of bank's profitability, IINC is the ratio of interest income to total assets, NII is the ratio of non-interest income to total assets, TRADEGAIN is the ratio net gain/loss from trading activities to total non-interest income, COM is the ratio of net fees and commissions to total non-interest income and EXTRA is the ratio of other non-interest income to total non-interest income. AFFECTED is a dummy is equal to 1 when the bank is a Dutch bank and 0 otherwise. POSTEVENT is a dummy equal to 1 for the years 2003 to 2006 and 0 otherwise. The model is estimated using OLS. The effect of LBR is captured by the coefficient on the interaction term Affected × PostEvent. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 9. Impact of LBR on bank interest margin, interest charged and funding cost

Variables	NIM (1)	INT (2)	COST (3)
Affected x PostEvent	-0.004**	-0.021**	-0.016**
	(0.002)	(0.009)	(0.006)
Year fixed effects	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes
Observations	261	261	261
R-squared	0.848	0.913	0.819

Notes: The table analyses the impact of the introduction of the Liquidity Balance Rule in the Netherlands on bank profit, equity and deposits in a difference-in-differences setup. The sample consists of banks from the Netherlands and the matched non-Dutch banks over the 2000-2006 period. COST is the ratio of total interest expenses to total liabilities, INT is the ratio of total interest income to total earning assets, and NIM is the difference between INT and COST (NIM = INT-COST). AFFECTED is a dummy is equal to 1 when the bank is a Dutch bank and 0 otherwise. POSTEVENT is a dummy equal to 1 for the years 2003 to 2006 and 0 otherwise. The model is estimated using OLS. The effect of LBR is captured by the coefficient on the interaction term Affected × PostEvent. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 10. Impact of LBR on bank funding structure

Variables	DEPOSITS (5)	EQUITY (6)
Affected x PostEvent	0.009**	0.019**
	(0.004)	(0.007)
Year fixed effects	Yes	Yes
Bank fixed effects	Yes	Yes
Observations	364	406
R-squared	0.963	0.927

Notes: The table analyses the impact of the introduction of the Liquidity Balance Rule in the Netherlands on bank profit, equity and deposits in a difference-in-differences setup. The sample consists of banks from the Netherlands and the matched non-Dutch banks over the 2000-2006 period. DEPOSITS is the ratio of total customer deposits to total assets and EQUITY is the ratio of total equity to total assets. AFFECTED is a dummy is equal to 1 when the bank is a Dutch bank and 0 otherwise. POSTEVENT is a dummy equal to 1 for the years 2003 to 2006 and 0 otherwise. The model is estimated using OLS. The effect of LBR is captured by the coefficient on the interaction term Affected × PostEvent. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 11. Robustness analysis and sensitivity tests

		Panel 1. Broad sample of banks				Panel 2. Subsample of listed banks			
		ZSCORE	Z1	Z2	SDROA	SDR	BETA	IVOL	MZ
(1)	Placebo test	0.193	0.647	0.176	-0.539	-0.157	-0.021	-0.190	0.162
		(0.264)	(0.766)	(0.264)	(0.751)	(0.175)	(0.024)	(0.213)	(0.182)
(2)	Broad sample	0.181**	0.029	0.174**	-0.617*	-0.234**	-0.342*	-0.225**	0.436**
		(0.091)	(0.052)	(0.107)	(0.352)	(0.112)	(0.253)	(0.109)	(0.146)
(3)	Without controls	0.3291**	0.369	0.309**	-0.416**	-0.361**	-0.661	-0.321**	0.362**
		(0.121)	(0.373)	(0.116)	(0.156)	(0.068)	(0.731)	(0.073)	(0.068)
(4)	4 Year rolling window	0.362***	0.442	0.335***	-0.556**				
		(0.105)	(0.572)	(0.104)	(0.209)				
(5)	5 Year rolling window	0.345**	0.337	0.339**	-0.498**				
		(0.130)	(0.502)	(0.135)	(0.187)				
(6)	Last 3 months					-0.263**	-0.934	-0.255**	0.319**
						(0.129)	(1.394)	(0.112)	(0.124)
(7)	Alternative matching	0.305**	0.571	0.296**	-0.356**	-0.262**	-0.522	-0.244**	0.262**
		(0.116)	(0.738)	(0.119)	(0.133)	(0.094)	(0.771)	(0.091)	(0.098)
(8)	1 neighbor	0.451***	0.618	0.413***	-0.832*				
		(0.115)	(0.824)	(0.113)	(0.498)				
(9)	5 neighbors	0.484**	0.462	0.472**	-0.547**				
		(0.181)	(0.689)	(0.173)	(0.204)				
(10)	Benelux only	0.305**	0.562	0.296**	-0.356**				
		(0.113)	(0.837)	(0.119)	(0.133)				
(11)	Belgium only	0.532**	0.320	0.476**	-0.687***				
		(0.201)	(0.468)	(0.179)	(0.157)				

Notes: The table presents the sensitivity of the baseline model to variations in the definition of the outcome variable, the sample size and matching procedure as well as false timing of the introduction of the LBR. For brevity, we only report the estimated coefficients of the variable of interest Affected × Post Event. The bank- and country-level controls as well as fixed effects are identical to those in Table 6. Row (1) conducts a placebo test by falsely assuming the LBR was implemented in 2001 rather than 2003. Row (2) considers the unmatched sample of banks while Row (3) excludes control variables from the estimated model. In rows (4) and (5), ZSCORE, Z1, Z2 and SDROA are measured using a four-year rolling and five-year rolling window. Row (6) uses the last three months of the year to compute SDR, BETA, IVOL and MZ. Row (7) use alternative variables for the matching procedure. Instead of the growth rate in ZSCORE and MZ, the growth rates of SDROA and SDR is used. Row (8) and (9) match each Dutch bank with one and five unaffected banks, respectively. Rows (10) and (11) restrict the number of countries from which banks in the control group are selected to Benelux (i.e., Belgium and Luxembourg) and Belgium, respectively. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

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