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Bank Liquidity Risk and Monetary Policy
Empirical Evidence on the Impact of Basel III Liquidity Standards

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We extend the literature on the bank lending channel in two aspects. First, rather than following the literature by analyzing the impact of banks' liquidity (measured via their asset portfolio) on monetary policy transmission, we study the role of banks' actual liquidity risk, as measured by the Basel III liquidity regulations. Second, we investigate the effect of complying with the Basel III liquidity standards on monetary policy transmission. We use highly detailed bank-level data from Luxembourg for the period 2003q1-2010q4. Our findings are that monetary policy transmission works its way through small banks that also have a large maturity mismatch, as measured by the Net Stable Funding Ratio. In contrast, large banks with a small maturity mismatch increase their lending following a monetary policy shock, which confirms existing results that Luxembourg's banks are liquidity providers to the European market. Based upon in-sample predictions and upon simulated data from an optimization model that takes the banks' business models into account, we conclude that the bank lending channel will no longer be effective once banks adhere to the new Basel III liquidity regulations.

Keywords: bank lending channel, monetary policy, liquidity risk, Basel III, dynamic panel estimation, simulation

JEL Classifications: E52, E58, G28.

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1. Introduction

Under conditions of imperfect information, monetary policy can affect the banks' credit supply through the bank lending channel.[1] The mechanism underlying this transmission channel operates when, after a policy-driven increase in short-term interest rates, banks are not able to compensate the reduction in core deposits with alternative sources of funding, inducing then restrictions in lending. As the literature has shown, this is likely to be the case for banks that hold neither sufficient liquidity nor sufficient capital buffers, or for small banks (Angeloni et al. 2003; Kashyap and Stein 1995; Ehrmann et al. 2002; Kishan and Opiela 2000; Chatelain et al. 2003; Peek and Rosengren 1995). Recent contributions on the bank lending channel stressed the role of financial innovation and the banks' risk profile for monetary policy transmission. Indeed, previous to the 2007 liquidity crisis, the tendency of banks to abandon the more traditional 'originate-and-hold' business model in favor of an 'originate-and-distribute' model enabled banks to raise funds from financial markets by issuing structured products (Hirtle 2008; Altunbas et al. 2009; Loutskina and Strahan 2009). Additionally, some banks, mostly investment banks, strongly increased their dependency on funding from short-term repo agreements. Overall, these trends in the banking industry have widened the asset-liability maturity mismatch and made it easier for banks to meet the regulatory requirements. Therefore, banks became more exposed to funding liquidity risk[2] and market liquidity risk.[3]

In this paper, we argue that the core relationship underlying the monetary policy transmission mechanism and banks' liquidity risk should be analyzed with a stronger focus on the regulatory requirements that the banks face. Thus, we extend the literature on the bank lending channel in two aspects. First, instead of only studying how banks' liquidity, measured simply through banks' liquid asset holdings, affects monetary policy transmission, we also analyze the role of banks' actual liquidity risk. We measure banks' liquidity risk based on the Basel III liquidity risk measures, the Liquidity Coverage Ratio (LCR) and the Net Stable Funding ratio (NSFR). These have been introduced by the Basel Committee on Banking Supervision (BCBS) (BCBS 2010), who recognized the need for further regulatory action in the light of the recent liquidity crisis. These ratios address the resilience of the liquidity risk profile of banks and are based on sophisticated models of liquidity analysis.[4] Secondly, this study is the first one, to the authors' knowledge, that quantitatively analyzes the impact of the new liquidity standards on monetary policy transmission. We use two methods for this. The first one relies on predictions based on the regression results. We use these predictions to estimate the impact of complying with the Basel III liquidity regulations on monetary policy. However, predictions based on the historical data suffer from two main issues. One, the out-of-sample predictions, and even in-sample ones, based on the historical data are

[1]The economic literature provides an extensive analysis of the mechanism underlying the transmission of monetary policy to the real economy. Surveys are available, among others, in Bernanke and Gertler (1995) or Cecchetti (1995).

[2]"*Funding liquidity* describes the ease with which investors can obtain funding from financiers. Funding liquidity is high when it is easy to raise money" (Brunnermeier et al. 2009).

[3]Market liquidity refers to the cost of raising money by selling-off assets in the market (Brunnermeier et al. 2009).

[4]There are, obviously, different ways to measure liquidity risk and measurement techniques are widely used by banks' managers. They range from a simple balance sheet liquidity analysis to models with variable degrees of sophistication, like the cash-capital analysis (from Moody's) and the maturity-mismatch analysis, which deal with features such as the time dimension, off-balance sheet commitments, marketability of securities and stability of funding sources (Neu 2007). The Basel III liquidity risk measures provide a unified measurement that takes into a variety of scenarios and assumptions, see Basel Committee on Banking Supervision (BCBS 2010).

likely to be less correct the larger the impact of the regulations on banks' balance sheets. Thus, banks that are far away from the regulatory requirements might have a totally different balance sheet after adhering. Two, a bank that does not meet the Basel III liquidity regulations is likely to optimally adjust its balance sheet and asset portfolios in order to comply with these regulations. In order to address these two problems, we simulate banks' balance sheets by minimizing a banks' loss function subject to the balance sheet constraints and the requirements of the new regulations. We then use this simulated data to study how the monetary policy transmission would have been if the regulations had already been put in place in 2003q1. This exercise is different from the regressions and predictions based on the historical data since we take into account the optimal balance sheet adjustments induced by the regulations.

The measurement of banks' liquidity risk, for example the calculation of the LCR and NSFR, necessitates detailed balance-sheet data. This is quite restrictive as data with the required level of granularity is usually confidential and only available in banking sector supervisory institutions. As a consequence, in order to perform this study we make use of bank-level data, collected quarterly by the Central Bank of Luxembourg from 2003q1 to 2010q4, for a sample covering between 82% and 100% of total assets of Luxembourg's banking sector. Luxembourg's banking sector, which represents around 30% of its Gross Domestic Product, is mainly composed of subsidiaries of European banking groups and plays the role of intra-group liquidity provider[1]. Accordingly, it is likely that Luxembourg contributes substantially to the transmission of the European Central Bank monetary policy across the Euro Area.

Our results are as follows. We find a significant role for the bank lending channel in Luxembourg, which mainly works through small banks with a large shortfall in the NSFR. Thus, small banks that are suffering from relatively large maturity mismatches, as measured by the NSFR shortfall, are those that are most affected by contractionary monetary policy shocks. In contrast, big banks are able to increase their lending following a policy-driven increase in the short-term interest rate. This result confirms previous studies that conclude that Luxembourgish banks are liquidity providers to the European banking sector (**?**Mevis 2012). Our results, thus, qualify further on previous findings in studies for other European countries that do not find that the size of a bank is a relevant characteristic for explaining distributional effects of monetary policy shocks (Angeloni et al. 2003). We show that a bank's size is a significant driver of monetary policy distributional effects but only if one also takes into account the current liquidity risk and maturity mismatch structure of a bank itself. Additionally, we provide a more detailed description of the underlying mechanism of the bank lending channel in Luxembourg by disaggregating the shortfalls into their components (i.e. the stock of high quality liquid assets, the net outflows, the required stable funding and the available stable funding). The results suggest that indicators of the width of the funding bases (i.e. net outflows, available stable funding) are more relevant for the identification of the bank lending channel in Luxembourg than qualifiers on the assets (e.g. liquidity).

Our findings regarding the impact of the new liquidity regulations lead us to the conclusion that the bank lending channel is likely to vanish as banks make their way to compliance. Adhering to the NSFR may reduce the reaction of the loan supply to monetary policy shocks more strongly than complying with the LCR. This was to be expected as any reduction in the maturity mismatch of a bank

[1]In case of Luxembourg, interbank lending mainly refers to intra-group lending activities. Throughout the article we use interbank and intra-group activities interchangeably.

strengthens the bank's position to cope with funding run-offs.

The article is organized as follows. Section 2 discusses some issues regarding liquidity risk measurement together with the Basel III liquidity regulations, namely the LCR and NSFR, more deeply. Section 3 describes the data and the empirical specification of the econometric model. The estimation results are presented in Section 4, while Section 5 concludes.

2. Liquidity risk measurement and Basel III standards

Our focus in this section is to introduce the main features of liquidity risk measurement and the Basel III liquidity standards. We also discuss the potential roles that the LCR and NSFR would have in altering the impact of monetary policy on bank lending.

Regarding liquidity, the risk that a bank faces is to meet the net cumulative cash outflows within a certain time period (e.g. one day, one month or longer). A bank that wants to stay solvent then has to generate enough cash inflows during the analyzed period in order to meet its outflows. Hence, the objectives of policies directed towards the reduction of liquidity risk, at the bank level, are twofold. On the one hand, banks attempt to minimize their net cumulative cash outflows. Here, liquidity management needs to keep track of the asset-liability maturity mismatch as the higher the mismatch the higher the net outflow. This requires precise assessments of the term structure of assets and liabilities as well as the stability of the later to shocks (e.g. stable and non-stable counterparts, off-balance sheet liquidity commitments). On the other hand, the focus is placed on the management of the unencumbered eligible assets stock so as to leave to the treasurer's discretion the amount needed to meet the net cumulative cash outflows (by selling them off or by using them as collateral in repurchase agreements). Here, the bulk of the analysis is on the marketability of the assets. For liquidity risk, the market or book value does not provide enough information. Instead, the future collateral or cash value when pledging or selling these securities is required. Hence, haircuts for future market value volatility have to be considered (Neu 2007).

Liquidity risk is commonly called a consequential risk. Generally, banks face liquidity problems after having incurred severe losses. Therefore, one should account for the fact that liquidity problems usually unfold in situations of bank-specific or market wide distress. Consequently, liquidity risk must be analyzed under different bank-specific and market-wide scenarios (Neu 2007).

The recent financial crisis uncovered the importance of liquidity positions and maturity mismatches in banks' portfolios. This led to a widespread agreement that there is a need for closer monitoring of the financial sector and for an improvement in the standards and regulatory practices. The BCBS has then launched a set liquidity risk monitoring and supervision tools. Among them, it suggests the introduction of the Liquidity Coverage Ratio (LCR) and the Net Stable Funding ratio (NSFR) (BCBS 2010).

2.1 The Liquidity Coverage Ratio

The LCR requires that banks hold high quality liquid assets to meet liquidity needs over a 30-day time horizon under an acute liquidity stress scenario. The LCR is thus a constraint on how much short-run liquidity risk a bank is allowed to hold. It is supposed to "promote short-term resilience of a bank's liquidity risk profile by ensuring that it has sufficient high-quality liquid assets to survive a significant stress scenario lasting for one month" (BCBS 2010, p.1.)

The LCR is defined as:

$$\mathrm{LCR}_{it} = \frac{\text{High Quality Liquid Assets}_{it}}{\text{Outflows}_{it} - \min(\text{Inflows}_{it}, 0.75 \cdot \text{Outflows}_{it})}.$$

The Basel committee's regulation then demands that banks have an LCR that exceeds one, suggesting that the stock of high-quality liquid assets (HQLA) covers the net outflows (NO). The net outflows for each bank in period t (NO_{it}), is defined as: $\mathrm{NO}_{it} = \text{Outflows}_{it} - \min(\text{Inflows}_{it}, 0.75 \cdot \text{Outflows}_{it})$. Thus, the LCR shortfall is given by:

$$\text{LCR shortfall}_{it} = \mathrm{NO}_{it} - \mathrm{HQLA}_{it}. \tag{1}$$

The HQLA encompasses cash, unencumbered high-quality securities and government debt[1]. One would expect that banks with more HQLA are, *ceteris paribus*, more liquid banks and, therefore, be able to more easily offset monetary policy shocks through selling their liquid assets even during distress periods. The NO encompasses all the expected outflow minus the expected inflow of money during one month. In the definition of Outflows the focus is on the stability of liabilities and on off-balance sheet contingent commitments. Funding from unstable sources receives a higher run-off factor in the definition of NO than stable funding. Similarly, the Inflows compound different sources of revenues within the 30-days horizon. In order to encourages banks to hold a buffer of HQLA, the Inflows are bounded at 75% of the Outflows. On the one hand, one would expect that a bank with higher NO faces a higher external finance premium because of the presumed lower resiliency of the bank's short-term liquidity risk profile. On the other hand, since bigger Outflows imply a bigger funding base due to a wider access to wholesale funding, one would expect that, during non stress periods, NO might be positively related to the ability of the bank to compensate for a reduction of core deposits.[2]

The introduction of the LCR as a regulatory standard is likely to improve the liquidity position of banks by encouraging them to modify their asset portfolio and the strategy for funding it. Banks are induced to hold a higher stock of unencumbered highly liquid low-risk securities (i.e. government bonds) and fewer short-term loans to financial institutions. This might reduce the impact of contractionary monetary policy shocks. Regarding the liability side, one would expect that banks tend to rely less on the market and on deposits from financial institution, and more on retail and on non-financial corporate deposits. Unlike the restructuring that we expect to happen on the asset side, the expected changes to the liability side should increase the reaction of the supply of loans to monetary policy developments.

2.2 The Net Stable Funding Ratio

The NSFR is established to "promote resiliency over longer-term time horizons by creating additional incentives for banks to fund their activities with more stable sources of funding on an ongoing basis " (BCBS 2010, p.1). It is defined as:

[1] The definition of HQLA is given in paragraphs 34 to 42 of Basel Committee for Banking Supervision (BCBS 2010).

[2] Given the cap on inflows, the relationship between the Outflows and the NO is expected to be monotonic.

$$\text{NSFR}_{it} = \frac{\text{Available Stable Funding}_{it}}{\text{Required Stable Funding}_{it}}.$$

The Basel regulation requires the NSFR ratio to exceed one. Then, the NSFR shortfall is given by:

$$\text{NSFR shortfall}_{it} = \text{Required Stable Funding}_{it} - \text{Available Stable Funding}_{it}. \quad (2)$$

The Available Stable Funding (ASF) consists of capital, liabilities with maturity greater than a year or those that are expected to be stable during a crisis. The amount of Required Stable Funding (RSF) places more weight on those assets that are less liquid during stress periods and therefore require a more stable source of funding. Thus, the NSFR focus is on a bank's maturity mismatch.

One would expect that the loan supply of those banks with a higher NSFR will be less responsive to monetary policy. Firstly, given that a bank's capital is one of the components of the available stable funding, a higher NSFR might be associated with less reliance on outside funding and a lower external finance premium. Secondly, the bigger the ASF the larger a bank's stable funding base which increases the resiliency of a bank to liquidity shocks. Additionally, banks that have a higher amount of ASF are, *ceteris paribus*, less subject to maturity mismatch. Finally, the amount of RSF consists mainly of long-term assets (i.e. exceeding one year) and loans to retail clients or non-financial corporate clients of maturity less than one year. It also includes off-balance sheet exposures. A bank with assets that have a maturity structure that tends to be longer is more likely to face significant maturity mismatch risk and might face a higher external finance premium. As a consequence, a bank with large RSF would tend to be affected more strongly by monetary policy than a bank with fewer RSF.

3. The econometric model and the data

3.1 Model specification and variables definition

The empirical specification, based on the standard literature for identifying the bank lending channel, is designed to test whether banks that show different balance sheet structures react differently to monetary policy shocks. This approach is in line with the works conducted by the ECB on monetary policy transmission (Angeloni et al. 2003) and with the studies of Altunbas et al. (Altunbas et al. 2009, 2010). Our contribution is to more carefully treat the banks liquidity risk by using, as additional bank characteristics, the shortfalls in the LCR and NSFR. Therefore, the regression model is specified as:

$$\begin{aligned}\Delta \log(L_{it}) = {} & \alpha_i + \beta_1 \Delta \log(L_{i,t-1}) + \beta_2 \Delta r_t + \beta_3 OGap_{t-1} \\ & + \sum_{h=1}^{z} \beta_{4h} x_{ih,t-1} + \sum_{h=1}^{z} \beta_{5h} x_{ih,t-1} \cdot \Delta r_t \\ & + \beta_6 \prod_{h=1}^{z} x_{ih,t-1} \cdot \Delta r_t + c_t + \epsilon_{it} \qquad (3)\end{aligned}$$

where $i = 1, ..., N$ and $t = 1, ..., T$ and where N denote the number of banks and T the number of quarters in the sample. L_{it} are the total loans of bank i in quarter t. Δr_t is the first difference of a nominal short-term interest rate, and represents a proxy for the change in monetary policy. $OGap_{t-1}$ is the output-gap which is defined as the difference between the potential and the observed output of the economy divided by the potential output[1]. It allows us to control for the evolution of loan demand. The dummy variable c_t equals one for those quarter within the last liquidity crisis period[2] and zero otherwise. The lagged bank-specific characteristics are given by $x_{ih,t-1}$. We include an interaction term between bank characteristics and the change in the level of monetary policy indicator, $\prod_{h=1}^{z} x_{ih,t-1} \cdot \Delta r_t$, aiming at testing for non-linear reactions of banks to monetary policy shocks. All bank characteristics are calculated as shares of total assets. Finally, the model allows for individual fixed effects.

As bank characteristics we consider the ratios of the LCR and NSFR estimated shortfalls over total assets (equations 1 and 2 respectively) and their components (i.e. the stock of HQLA, NO, ASF and RSF). Through this we aim at assessing to which extent the degree of compliance to the ratios captures the heterogeneous reactions of the banks to monetary policy shocks. Indeed, this give us a hint about the effectiveness of monetary policy transmission following the implementation of the new liquidity regulation. We study the robustness of our results by following the literature and considering indicators of size (i.e. the logarithm of total assets), capitalization (i.e. the ratio of capital over total assets) and liquidity (i.e. the ratio of HQLA over total assets[1]). Size and capitalization are largely used as measures of a bank's health and related to its external finance premium. The level of a bank's liquidity is not a clear-cut measure of bank health. However, liquidity may reduce the effects of a monetary policy tightening to the extent that it allows quicker adjustments to the asset side after a change in the external funding.

3.2 *The data*

We make use of data from the statistical reporting of banks to the Banque centrale du Luxembourg. We build an unbalanced panel for the period spanning 2003q1 to 2010q4 and have quarterly observations on balance sheet characteristics for a maximum of 157 banks per quarter (and a minimum of 68 banks)[2]. Our monetary policy indicator comes from the ECB Statistical Data Warehouse and is the Euribor 3 month interest rate.

Table 1 depicts descriptive statistics on the variables used in the econometric analysis by quartile of the distribution of the bank size variable;[3] This table points out the significant role of the size variable to summarize other balance sheet characteristics of banks. Big banks' average growth rate of loans is higher than the one of small banks.[4] Also, small banks have a higher ratio of LCR shortfall over total assets than big banks, mainly because of the differences in the ratio of HQLA over

[1]The potential output is estimated through the Hodrick-Prescott filter.
[2]We consider 2007q3 as the starting quarter which corresponds to the beginning of the financial turbulence (ECB Monthly Bulletin (European Central Bank 2010)).
[1]The definition of HQLA in the LCR is more restrictive than the definition of liquid assets as used in the mainstream literature.
[2]In the last three quarters we make use of a sample of banks representing between 82% and 95% of the sector's total assets. This is due to a change in the reporting rules of the Eurosystem of Central Banks which made the statistical reporting non-mandatory for small banks.
[3]We have cleaned the sample from outliers by cutting the tails of the relevant variables at the 1th and 99th percentiles. Table 1 is based upon the cleaned sample.
[4]We consider as small (big) banks those in the first (fourth) quartile of the total assets distribution. Medium-sized banks are those in the second and third quartiles.

Table 1. Descriptive statistics on historical data by quartile of total assets.

Quartiles of Size	**Variables**	Statistics N	Mean	St.Dev.	Min	Max
1	Δ ln(loans)	794	0.002	0.194	-0.875	0.669
	Size	794	19.184	0.705	17.251	20.102
	LCR shortfall	794	0.029	0.091	-0.278	0.600
	NSFR shortfall	794	-0.156	0.281	-0.834	0.698
	HQLA	794	0.042	0.055	0.000	0.367
	Net Outflows	794	0.071	0.084	0.000	0.616
	Avail.Stable Fund.	794	0.456	0.245	0.058	0.976
	Requi.Stable Fund.	794	0.300	0.212	0.002	0.964
	Capitalisation	794	0.088	0.078	0.008	0.538
2	Δ ln(loans)	793	-0.000	0.208	-0.954	0.669
	Size	793	20.751	0.364	20.105	21.392
	LCR shortfall	793	0.062	0.146	-0.248	0.599
	NSFR shortfall	793	0.024	0.235	-0.539	0.702
	HQLA	793	0.048	0.064	0.000	0.320
	Net Outflows	793	0.110	0.133	0.000	0.617
	Avail.Stable Fund.	793	0.302	0.189	0.008	0.846
	Requi.Stable Fund.	793	0.326	0.233	0.002	0.856
	Capitalisation	793	0.035	0.047	0.000	0.479
3	Δ ln(loans)	793	0.005	0.202	-0.856	0.638
	Size	793	22.071	0.407	21.394	22.799
	LCR shortfall	793	0.054	0.116	-0.245	0.590
	NSFR shortfall	793	0.067	0.235	-0.594	0.693
	HQLA	793	0.036	0.041	0.000	0.348
	Net Outflows	793	0.090	0.106	0.002	0.612
	Avail.Stable Fund.	793	0.296	0.192	0.006	0.790
	Requi.Stable Fund.	793	0.363	0.242	0.003	0.931
	Capitalisation	793	0.030	0.051	0.000	0.559
4	Δ ln(loans)	793	0.005	0.164	-0.783	0.661
	Size	793	23.518	0.512	22.800	24.671
	LCR shortfall	793	-0.025	0.103	-0.302	0.513
	NSFR shortfall	793	0.146	0.148	-0.323	0.605
	HQLA	793	0.082	0.085	0.000	0.345
	Net Outflows	793	0.056	0.068	0.001	0.590
	Avail.Stable Fund.	793	0.267	0.147	0.014	0.728
	Requi.Stable Fund.	793	0.412	0.204	0.008	0.811
	Capitalisation	793	0.021	0.017	0.001	0.131
Total	Δ ln(loans)	3173	0.003	0.193	-0.954	0.669
	Size	3173	21.380	1.683	17.251	24.671
	LCR shortfall	3173	0.030	0.121	-0.302	0.600
	NSFR shortfall	3173	0.020	0.255	-0.834	0.702
	HQLA	3173	0.052	0.066	0.000	0.367
	Net Outflows	3173	0.082	0.103	0.000	0.617
	Avail.Stable Fund.	3173	0.330	0.210	0.006	0.976
	Requi.Stable Fund.	3173	0.350	0.227	0.002	0.964
	Capitalisation	3173	0.043	0.059	0.000	0.559

total assets rather than in the NO ratio. Conversely, the NSFR shortfall is lower for smaller banks mostly because small banks tend to be better capitalized.

In order to identify the bank lending channel of monetary policy transmission, standard practice considers the loans to non-financial corporates (NFC) and retail customers in the econometric analysis. We deviate from that by using total loans. Since NFC and retail loans of Luxembourgish banks only add-up to less than 14 percent of total assets (see Table 2) and less than 18 percent of total loans, the standard practice would give a constrained picture of the ECB monetary policy

Table 2. Average ratio of loans over total assets by quartiles of bank size.

Quartiles of Size	**Loans to**				
	Total	**NFC**	**Retail**	**MFI**	**Other**
1	0.831^{*}	0.064^{***}	0.079	0.662^{**}	0.026^{***}
	(0.212)	(0.131)	(0.158)	(0.268)	(0.072)
2	0.849^{***}	0.083	0.081^{***}	0.637^{***}	0.048^{***}
	(0.187)	(0.130)	(0.167)	(0.253)	(0.085)
3	0.818^{***}	0.090^{**}	0.045^{***}	0.607^{***}	0.076
	(0.231)	(0.150)	(0.097)	(0.262)	(0.095)
4	0.667	0.081	0.025	0.482	0.079
	(0.249)	(0.114)	(0.053)	(0.256)	(0.086)
Total	0.791	0.080	0.057	0.597	0.057
	(0.233)	(0.132)	(0.130)	(0.269)	(0.087)

Standard errors in parenthesis.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3. Correlation factors between growth rate of loans to the different sectors

$\Delta ln(loans)_{j,t-1}$	j				
j	Total	NFC	Retail	MFI	Other
Total	1.000				
NFC	0.075	1.000			
	(0.000)				
Retail	0.098	0.020	1.000		
	(0.000)	(0.282)			
MFI	0.693	0.018	0.053	1.000	
	(0.000)	(0.298)	(0.004)		
Others	0.135	0.000	0.037	0.035	1.000
	(0.000)	(0.992)	(0.055)	(0.049)	

p-values in parenthesis

transmission through Luxembourg's banking sector[1]. In the case of Luxembourg, combining loans granted to different sectors is likely to be neutral for the analysis of monetary policy transmission as they tend to react similarly to a monetary policy shock. Table 3 shows that the correlation between the growth rate of total loans and the growth rate of loans to the different sectors is positive and significant in every case. Moreover, Table 3 also shows that there are no significant negative correlations between the growth rate of loans to the different counterparties. This indicates that there are no substitution effects that the use of total loans would hide. In addition, the differences in the distribution of total loans among the economic sectors for banks of different sizes (see Table 2) do not seem to invalidate the assumption of a homogeneous demand for loans in the Luxembourgish banking sector.

[1]The assumption underlying the consideration of total loans in the regression analysis is that loans to financial institutions will feed, sooner or later, European economic activity and the price level. This assumption is likely to hold as, on average, two thirds of loans granted to financial institutions by banks in Luxembourg remain within the geographical limits of the current Euro-zone. Additionally, taking into account that the Euro-zone is one of the biggest open economies in the world, any modification to the real exchange rate of its' commercial partners is likely to impact, in the medium-term, the European price level and activity.

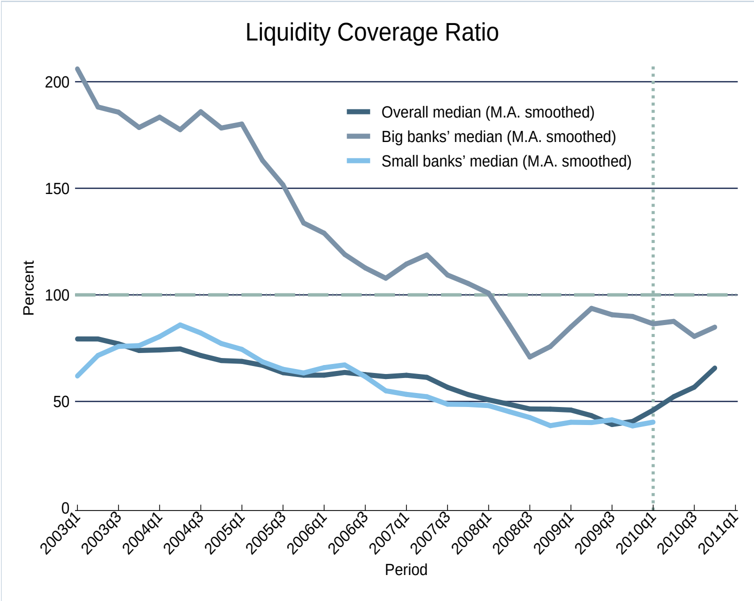

Figure 1. LCR median, 2003q1-2010q4. Full sample and 1th and 4th quartiles of total assets. *The vertical line at period 2010q1 shows when the sample changes from the full one to the reduced one due to the modification in the reporting.*

3.2.1 A closer look at the evolution of the LCR and NSFR

In the following paragraphs we provide a description of the evolution of the LCR and NSFR for a representative sample of banks in Luxembourg from 2003q1 to 2010q4.

Figure 1 shows the evolution of the LCR median. A distinction should be made for the last three periods of the series because of the changes in the sample that followed the modifications in the reporting rules (see footnote 2). We draw the median over the full sample, as well as the median value for the first (i.e. small banks) and fourth (i.e. big banks) quartiles of total assets. The smoothed median of the LCR declined from a maximum of 80% in 2003 Q4 to a minimum of 39% by the end of 2009. It stands at 65% in 2010q4, but potentialy due to the reduced sample. In the aftermath of the crisis the LCR started to recover essentially due to big banks.

Figure 2 shows that the median of the NSFR was initially above 100% before 2005, but declined continuously until the start of the crisis to a level of 80%. It then recovered mainly due to small banks. The evolution of the NSFR over time should be ascribed to a process of change in financial practices. Loans to NFCs have been increasing as well as longer-term loans that are secured by real estate. The increases in capital are too small to compensate for these enlargements on the asset side, which are funded by wholesale borrowing. The cuts in the loan supply due to the dry-out of money markets and the re-capitalizations observed during the crisis have triggered the recovery of the NSFR.

It is worth noting the significant differences in the median of the LCR and NSFR between big and small banks. Big banks fare better in terms of the LCR but worse in terms of the NSFR. This can be attributed to several crucial differences in the balance sheet characteristics. As discussed above, the main differences lie in the share of NO, ASF and RSF over total assets (see Table 1). These differences also help to explain the jumps observed in the series of the LCR and the NSFR in 2010q2 when smaller banks were released from reporting obligations.

This short description hints at the potentially sizable modifications of banks'

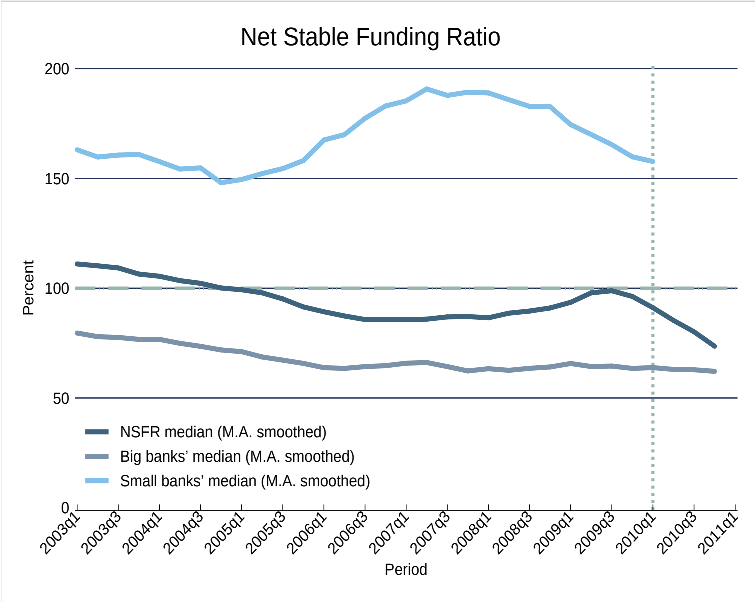

Figure 2. NSFR median, 2003q1-2010q4. Full sample and 1th and 4th quartiles of total assets. *The vertical line at period 2010q1 shows when the sample changes from the full one to the reduced one due to the modification in the reporting.*

balance sheets that compliance with the ratios is likely to require. We, thus, argue that it is necessary to forecast the potential restructuring of banks' balance sheets and the implications for policy making. In the next subsection we describe the outcome of a simulation exercise we performed with this aim in mind.

3.2.2 Balance sheets adjustments toward compliance: a simulation exercise

We carried out a simulation exercise in order to assess the optimal balance sheet adjustments that compliance with the LCR and NSFR would require. The simulated model assumes that, in each period and given a vector of prices and adjustment costs, the banks maximize profits by selecting the amount of total loans, Level 1 and Level 2 securities, capital, and different categories of deposits, under the constraint of complying with the LCR, NSFR and minimum capital requirements. The details on the variables definitions, the simulation procedure and the optimization program are available from the authors upon request. A similar approach has been used in Kopecky and VanHoose (2004).

The results of the simulation model are summarized in Table 4. It presents descriptive statistics, by quartiles of size, of the components of the standards, namely the ratios of HQLA, NO, ASF and RSF over total assets, as well as the share of the shortfalls in LCR and NSFR over total assets and the leverage ratio.

The comparison of Table 4 with Table 1 reveals how banks of different sizes comply with the standards in our simulation. On average, banks in the third and fourth quartiles of total assets mainly increase the ASF, rather than reduce the RSF, in order to adhere to the NSFR requirements. Regarding the LCR, moderate changes in the HQLA and the NO suffice for these larger banks to comply. The most sizable changes are undertaken by medium-sized banks with increases in basically all components of the LCR and NSFR while small banks increase both their HQLA and their RSF.

The adjustments in the components of the ratios suggest a restructuring of balance sheets that potentially affects the transmission of monetary policy shocks through the bank lending channel. If the LCR and NSFR sufficiently summarize

Table 4. Descriptive statistics on simulated data by quartile of total assets.

Quartiles of Size	**Variables**	N	Mean	St.Dev.	Min	Max
1	Δ ln(loans)	724	-0.0120	0.2183	-1.9083	1.0690
	Size	724	19.5225	0.5386	17.5586	20.1686
	LCR shortfall	724	-0.0529	0.0772	-0.3451	0.0000
	NSFR shortfall	724	-0.0399	0.1279	-0.9565	0.0000
	HQLA	724	0.1120	0.0873	0.0001	0.3536
	Net Outflows	724	0.0591	0.0630	0.0000	0.2936
	Avail.Stable Fund.	724	0.5027	0.1577	0.0913	0.9839
	Requi.Stable Fund.	724	0.4627	0.1822	0.0052	0.9822
	Capitalisation	724	0.4800	0.1787	0.0696	0.9839
2	Δ ln(loans)	723	0.0029	0.2032	-1.1518	0.6366
	Size	723	20.7270	0.3216	20.1711	21.2713
	LCR shortfall	723	-0.1485	0.1125	-0.3390	0.0000
	NSFR shortfall	723	-0.0448	0.1404	-1.3614	0.0000
	HQLA	723	0.1892	0.1054	0.0008	0.3851
	Net Outflows	723	0.0406	0.0558	0.0000	0.2904
	Avail.Stable Fund.	723	0.5491	0.1586	0.0777	1.3768
	Requi.Stable Fund.	723	0.5043	0.2013	0.0089	0.9817
	Capitalisation	723	0.4770	0.2326	0.0600	0.9817
3	Δ ln(loans)	723	0.0051	0.2156	-0.9819	0.6761
	Size	723	21.8694	0.4207	21.2716	22.7208
	LCR shortfall	723	-0.0700	0.1139	-0.3503	0.0000
	NSFR shortfall	723	-0.1336	0.2112	-1.3019	0.0000
	HQLA	723	0.1107	0.1156	0.0014	0.3503
	Net Outflows	723	0.0406	0.0497	0.0000	0.2885
	Avail.Stable Fund.	723	0.4538	0.2092	0.0601	1.3643
	Requi.Stable Fund.	723	0.3202	0.2037	0.0039	0.9824
	Capitalisation	723	0.1840	0.2049	0.0600	0.9824
4	Δ ln(loans)	723	0.0005	0.1634	-0.7467	0.6504
	Size	723	23.5646	0.5236	22.7212	24.7140
	LCR shortfall	723	-0.0781	0.0990	-0.3493	0.0000
	NSFR shortfall	723	-0.0426	0.1136	-0.7990	0.0000
	HQLA	723	0.1131	0.0991	0.0009	0.3798
	Net Outflows	723	0.0350	0.0301	0.0000	0.2720
	Avail.Stable Fund.	723	0.4084	0.1575	0.0657	1.2291
	Requi.Stable Fund.	723	0.3658	0.1743	0.0008	0.7965
	Capitalisation	723	0.0824	0.0830	0.0600	0.5461
Total	Δ ln(loans)	2893	-0.0009	0.2013	-1.9083	1.0690
	Size	2893	21.4202	1.5597	17.5586	24.7140
	LCR shortfall	2893	-0.0874	0.1080	-0.3503	0.0000
	NSFR shortfall	2893	-0.0652	0.1579	-1.3614	0.0000
	HQLA	2893	0.1312	0.1076	0.0001	0.3851
	Net Outflows	2893	0.0438	0.0519	0.0000	0.2936
	Avail.Stable Fund.	2893	0.4785	0.1800	0.0601	1.3768
	Requi.Stable Fund.	2893	0.4133	0.2044	0.0008	0.9824
	Capitalisation	2893	0.3059	0.2545	0.0600	0.9839

the structure of a bank's balance sheet then they should be able to explain distributional effects of monetary policy shocks. The next section deals with this issue.

4. Estimation results

In this section we present the results of the econometric estimation of alternative specifications of the model introduced in equation 3. We run both ordinary least squares and within estimator regressions. However, the inclusion of the lagged dependent variable as a regressor as well as of potentially endogenous variables like the balance sheet characteristics[1] is likely to introduce a dynamic-panel bias. The dynamic-panel bias occurs if there is a correlation between the lagged dependent variable and the fixed effects in the error term (Nickell 1981). In order to overcome this potential bias we resort to a Generalized Method of Moments (GMM) estimator dubbed the system-GMM estimator (Holtz-Eakin et al. 1988; Arellano and Bond 1991; Arellano and Bover 1995; Blundell and Bond 1998). We perform standard specification tests (i.e. non-autocorrelation of the errors, exogeneity of the matrix of instruments, rule-of-thumb for number of instruments). Additionally, aiming at ensuring that the bias is minimized, we verify that the coefficient of the lagged dependent variable estimated using the system-GMM estimator falls in the interval given by the ordinary least squares coefficient and the within estimator one. We systematically check that the number groups is smaller that the number of instruments, preserving thereby the reliability of the instruments exogeneity test. Finally, aiming at performing sound inferences and dealing with potential heteroscedasticity and inter-group multicollinearity, we make use of two-step robust standard errors estimator (yielding the Windmeijer correction). In effect, the standard errors thus obtained are consistent in the presence of any pattern of heteroscedasticity and autocorrelation within panels[2].

4.1 Monetary Policy Transmission

This section is based on the historical data series. We, firstly, ask whether the shortfalls in the LCR and NSFR ratios are able to explain heterogeneous movements in the growth rate of total loans driven by a monetary policy shock. Secondly, we add granularity to our analysis by disaggregating the shortfalls into their components. Our main concern is whether there is a significant interaction between the shortfalls in Basel III liquidity ratios and the short-term interest rate. If the coefficients of these interactions are statistically significant, then the shortfalls explain the distributional effects of monetary policy shocks[1]. Table 5 depicts the estimated coefficients of the alternative specifications discussed in this sub-section. Based on these results, intra-sample predictions of the long-term marginal effects of a contractionary monetary policy shock on the growth rate of total loans are shown in Tables 6 to 9.

We start-off the analysis of the monetary policy effects using the specification that combines the shortfalls in both ratios. Looking at model 1 in the first two columns of Table 5, one can see that the main bank characteristics that drives the heterogeneous reactions of the growth rate of total loans are the size and the NSFR shortfall. Table 6 presents the long-term marginal effects of a contractionary monetary policy shock predicted using this model. We observe that the bank lending channel in Luxembourg works through the smallest banks with a large shortfall in the NSFR. On average, banks in the first quartile of total assets and in the last quartile of the NSFR shortfall over total assets reduce total loans by 0.152% after an increase of one percentage point in the short-term interest rate. This result prevails since banks with a lack of stable funding are more inclined to lose funds following a contractionary monetary policy shock. Moreover, if these banks

[1]We consider the interest rate as exogenous given the relatively small size of Luxembourgish loans in the European economy.
[2]The specification presented in equation 3 includes regressors that vary only across the time dimension, this is expected to control for potential cross sectional dependencies correlation.
[1]From now “a monetary policy shock” refers to a one point increase in the short-term interest rate.

Table 5. Estimation results of the growth rate of total loans. Banks' characteristics: LCR and NSFR shortfalls disaggregated

	(1) Shortfalls		(2) LCR-sh.Dis.		(3) Liq.As.	
Δ ln(loans)$_{t-1}$	-0.139***	(0.0411)	-0.134***	(0.0403)	-0.137***	(0.0368)
Δr_t	-0.884**	(0.422)	-0.533*	(0.309)	-1.047**	(0.424)
Output-Gap$_{t-1}$	0.232	(0.179)	0.213	(0.185)	0.374**	(0.168)
NSFR-short.$_{t-1}$	0.132**	(0.0653)	0.214***	(0.0686)		
NSFR-sh.$_{t-1} \cdot \Delta r_t$	-0.135*	(0.0754)	-0.116*	(0.0671)		
LCR-short.$_{t-1}$	-0.0215	(0.0707)			-0.0291	(0.186)
LCR-sh.$_{t-1} \cdot \Delta r_t$	0.0604	(0.0831)			0.0435	(0.112)
Size$_{t-1}$	-0.00347	(0.0222)	-0.00932	(0.0207)	0.0121	(0.0232)
Size$_{t-1} \cdot \Delta r_t$	0.0417**	(0.0192)	0.0254*	(0.0142)	0.0487***	(0.0187)
Liq.$_{t-1}$			-0.377*	(0.205)		
Liq.$_{t-1} \cdot \Delta r_t$			0.381**	(0.167)		
NO$_{t-1}$			-0.156	(0.125)		
NO$_{t-1} \cdot \Delta r_t$			-0.150*	(0.0848)		
Req.Fund.$_{t-1}$					0.239***	(0.0902)
Req.Fund.$_{t-1} \cdot \Delta r_t$					-0.160**	(0.0639)
Av.Fund.$_{t-1}$					0.236**	(0.110)
Av.Fund.$_{t-1} \cdot \Delta r_t$					0.173*	(0.0980)
Obs.	3173		3173		3173	
Hansen, p.v.	0.300		0.230		0.421	
AR(1) p.v.	3.28e-10		3.47e-10		1.86e-10	
AR(2) p.v.	0.871		0.751		0.966	
Groups (Instr.) Nr.	130(97)		130(123)		130(112)	
Wald, p.v.	1.67e-15		1.66e-15		2.19e-18	

Standard errors in parentheses. Sample period: 2003q1-2010q4. Seasonal dummies are included.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

are small it would be harder for them to access alternative sources of funding.

A further look at the predictions in Table 6 reveals that medium-sized banks do not react to monetary policy shocks, while big banks with a small NSFR-shortfall increase their loans by 0.123%. The explanation for the positive reaction of bigger banks' loan supply following a tightening in the monetary policy is that Luxembourg's banking sector plays the role of a liquidity provider to their group. A stricter monetary policy stance increases the demand for funds which is partly satisfied by an increase in loans from Luxembourg's banks[1]. In addition, Luxembourg's large banks have a lower ratio of loans over total assets (compared to small banks) which gives them additional degrees of freedom to adjust other assets when faced with a reduction of core deposits. Of course, larger banks also tend to have a better access to short-term wholesale funding.

We turn now to the analysis of models disaggregating the shortfalls into their components. The second pair of columns in Table 5 (model 2) presents the specification which includes the components of the LCR, namely NO and HQLA. The estimated coefficients of the interaction terms between the bank characteristics and the monetary policy indicator are statistically significant. As we observed in model 1, the NSFR shortfall increases the sensitivity of banks vis--vis a monetary policy tightening. Likewise, smaller banks are affected more strongly. In line with the bank lending channel literature, model 2 shows that banks with higher shares of

[1]**?** show that the assets of Luxembourg's banking sector are positively correlated with the spread between the Euribor 3 month rate and the EONIA rate. This means that in times of liquidity needs the demand for credits from banks in Luxembourg increases.

Table 6. Average Long-term Marginal Effect of a Monetary Policy shock by quartiles of banks' size and NSFR shortfalls (based on Model 1)

Quartiles of NSFR-short	Quartiles of Size 1	2	3	4	Total
1	-0.042	0.003	0.073***	0.123***	-0.018
	(0.274)	(0.455)	(0.002)	(0.004)	(0.244)
2	-0.069	-0.010	0.042***	0.112***	0.008
	(0.168)	(0.537)	(0.002)	(0.003)	(0.143)
3	-0.106	-0.035	0.028*	0.097***	0.036**
	(0.118)	(0.298)	(0.062)	(0.002)	(0.019)
4	-0.152*	-0.080	-0.005	0.058***	-0.002
	(0.098)	(0.180)	(0.464)	(0.005)	(0.138)
Total	-0.059	-0.020	0.033**	0.088***	0.004
	(0.195)	(0.355)	(0.021)	(0.003)	(0.142)

p-values in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The coefficients in this table can be interpreted as the elasticity of total loans with respect to the short-term interest rate.

HQLA are better prepared to cushion monetary policy contractionary shocks. By contrast, the bank lending channel is more likely to operate through banks with high a NO ratio. In fact, even if a higher NO ratio represents a larger funding base, it is essentially a more unstable one (see section 2.1). The later estimation results contrast with those of model 1 where the LCR shortfall came out as insignificant. The intuition is based upon the observation that banks can 'trade' the LCR shortfall by borrowing short term (i.e. increasing the NO) in order to fund a higher stock of HQLA. This operation allows bank to improve their LCR and generate a positive correlation between the two components of the ratio. Consequently, the LCR shortfall might be bereft of statistical significance while the disaggregated specification (i.e. model 2) tends to more precisely capture the underlying effects.

On the basis of model 2, Tables 7 and 8 depict for each quartile of the size variable, the intra-sample predictions of the long-term marginal effects of a contractionary monetary policy by quartiles of, respectively, HQLA and NO. Despite that the estimated coefficients fit theoretical predictions and economic intuition, both tables show that, on average, the bank lending channel was not strongly active in our sample. More specifically, the negative predicted long-term marginal effect are not significantly different from zero. Beside this, one can see from these tables that the marginal effects of a monetary policy shock are not significant for small and medium sized banks though the loan growth rate of big banks react positively. In particular, big banks increase the growth rate of loans by 0.074%, on average, following a one percent increase in the short-term interest rate (4th quartile of size and row Totals in Table 7). The marginal effect can reach up to 0.121% on average if the bank posesses a sufficiently high HQLA ratio (4th quartiles of size and HQLA in Table 7). Moreover, big banks' average increase in the growth rate of loans reduces to 0.061% following a one percent increase in the short-term interest rate, but only if they are more strongly funded through unstable sources (4th quartile of size and NO in Table 8).

Finally, we analyze a specification that includes the NSFR shortfall's components (i.e. ASF and RSF) as regressors. The estimated coefficients are shown in the third couple of columns in Table 5 (model 3). As anticipated, the availability of stable funding prevents total loans to diminish after a monetary policy shock. Also,

Table 7. Average Long-term Marginal Effect of a Monetary Policy shock by quartiles of banks' size and HQLA (based on Model 2)

Quartiles of HQLA	Quartiles of Size 1	2	3	4	Total
1	-0.043	-0.028	0.016	0.061*	-0.002
	(0.286)	(0.241)	(0.244)	(0.079)	(0.205)
2	-0.012	-0.015	0.017	0.049*	0.004
	(0.428)	(0.272)	(0.299)	(0.086)	(0.286)
3	-0.017	0.010	0.022	0.048*	0.018
	(0.479)	(0.239)	(0.253)	(0.068)	(0.270)
4	0.001	0.030	0.061**	0.121***	0.071**
	(0.471)	(0.297)	(0.030)	(0.004)	(0.029)
Total	-0.020	0.000	0.021	0.074**	0.018
	(0.421)	(0.263)	(0.254)	(0.039)	(0.207)

p-values in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The coefficients in this table can be interpreted as the elasticity of total loans with respect to the short-term interest rate.

Table 8. Average Long-term Marginal Effect of a Monetary Policy shock by quartiles of banks' size and Net Outflows (based on Model 2)

Quartiles of NO	Quartiles of Size 1	2	3	4	Total
1	-0.004	0.017	0.054**	0.074**	0.031
	(0.454)	(0.402)	(0.040)	(0.030)	(0.227)
2	-0.021	0.014	0.020	0.076**	0.025
	(0.388)	(0.299)	(0.312)	(0.037)	(0.183)
3	-0.020	-0.008	0.018	0.075**	0.017
	(0.471)	(0.217)	(0.316)	(0.030)	(0.193)
4	-0.029	-0.038	0.011	0.062*	-0.008
	(0.344)	(0.144)	(0.369)	(0.091)	(0.268)
Total	-0.020	0.000	0.021	0.074**	0.018
	(0.421)	(0.263)	(0.254)	(0.039)	(0.207)

p-values in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The coefficients in this table can be interpreted as the elasticity of total loans with respect to the short-term interest rate.

the ratio of RSF over total assets enhances the transmission of contractionary monetary policy shocks. As it was the case in model 1, the LCR shortfall does not explain any heterogeneous reaction to monetary policy shocks but the size indicator does. Likewise, bigger banks are better prepared to cushion a monetary policy tightening. The intra-sample predictions of the long-term marginal effects of contractionary monetary policy are given in Table 9 for the small and big banks subsamples. On average, small banks with high ratios of RSF (4th quartile of RSF) or small ratios of ASF (1st quartile of ASF), reduce total loans by 0.141% following a 100 basic point increase in the short-term interest rate. The predicted long-term marginal effects of small banks increase as the ASF ratio grows reaching -0.078% and -0.049% in, respectively, the fourth and third quartile of RSF. However, these effects are no longer significantly different from zero in the second and first quartiles of RSF. Regarding big banks, the predicted long-term marginal effects are positive and significantly different from zero for the first and second quartiles of RSF independently of the level ASF. Nevertheless, the negative effect from RSF overcomes the positive effect from ASF (see in Table 9 the columns corresponding to the third and fourth quartiles of RSF).

The long-term marginal effects of a monetary policy tightening estimated using this specification for both small and big banks correspond to those predicted on the basis of model 1. This suggests that the results are robust across different specifications. Besides this we check the robustness of the previous results by estimating more detailed specifications not presented but available from authors. We explore models combining components of LCR and NSFR shortfalls. We find that our analysis above is robust to a multitude of different specifications and fits previous results in the literature. We conclude then that the LCR and NSFR convey relevant information for measuring the impact of monetary policy on bank lending.

4.2 The impact of compliance with the new standards on the bank lending channel

The results presented in the previous section give us an understanding of how banks with different ratios of the Basel III liquidity regulations reacted to monetary policy shocks in Luxembourg during the past years. In order to understand the potential impact of compliance with the Basel III regulations we perform two complementary analyses in this sub-section. First, using the results from model 1 we calculate out-of-sample predictions of the elasticities of the long-term marginal effects of a contractionary monetary policy shock with respect to changes in the shortfalls.

However, a potential limitation of this analysis is the neutrality assumption of the balance sheet modifications adopted to reach compliance with the standards. Indeed, a reduction in the shortfalls can hide substitution effects between the banks' balance sheet components that might modify the mechanism of monetary policy transmission. In order to overcome this weakness we adopt an alternative approach. We perform a counterfactual exercise that consists in fitting alternative specifications of equation 3, similar to the previously described regression models, but using our simulated bank level data.[1] We use the simulated data to econometrically estimate the long-term marginal effects of a monetary policy shock directly.

Table 10 depicts the elasticities of the monetary policy marginal effects with respect to changes in the shortfall of the NSFR and LCR standards. The analysis of these tables allows us to conclude that complying with the NSFR would reduce the importance of the bank lending channel in Luxembourg. However, complying with the LCR would not significantly affect the relevance of the bank lending channel.

In the last row of Table 10 we can see that a one percent increase of the ratio of NSFR shortfall over total assets would reduce, on average, the long-term marginal effect of a monetary policy contractionary shock by 0.07%. Thus, a higher NSFR shortfall implies larger reactions of the loan supply after a shock. The elasticities are negative and statistically significant for all the quartiles of the LCR shortfall. However, the elasticities decrease, in absolute value, as the LCR shortfall increases. In other words, the impact of a monetary policy shock on loans is less sensitive to changes in the NSFR shortfall for banks having more unstable funding bases (i.e. higher NO ratio) or lower shares of HQLA over total assets.

[1] For the sake of simplicity and space issues the estimation results are not exposed here. They are readily available under request to the authors.

Table 9. Average Long-term Marginal Effect of a Monetary Policy shock. Model 4. First and fourth quartiles of banks' size.

Quartiles of ASV	Quartiles of RSF									
	Small banks					*Big banks*				
	1	2	3	4	Total	1	2	3	4	Total
1	-0.038	-0.100	-0.095*	-0.141*	-0.068	0.049**	0.057***	0.017	-0.051	0.033
	(0.390)	(0.106)	(0.079)	(0.050)	(0.185)	(0.038)	(0.009)	(0.234)	(0.220)	(0.140)
2	-0.052	-0.078	-0.131**	-0.117**	-0.081	0.038*	0.091***	0.040*	0.043*	0.055**
	(0.227)	(0.113)	(0.040)	(0.043)	(0.103)	(0.087)	(0.001)	(0.060)	(0.056)	(0.013)
3	-0.042	-0.045	-0.066*	-0.116**	-0.058	0.092***	0.062***	0.063***	0.068**	0.067***
	(0.201)	(0.130)	(0.072)	(0.028)	(0.115)	(0.002)	(0.003)	(0.008)	(0.018)	(0.009)
4	-0.052	-0.022	-0.049*	-0.078**	-0.050	0.136***	0.053***	0.103***	0.054	0.059**
	(0.160)	(0.172)	(0.088)	(0.041)	(0.107)	(0.003)	(0.006)	(0.007)	(0.160)	(0.043)
Total	-0.046	-0.047	-0.076*	-0.108**	-0.061	0.053**	0.074***	0.043	0.047	0.054**
	(0.256)	(0.128)	(0.062)	(0.042)	(0.119)	(0.017)	(0.002)	(0.022)	(0.103)	(0.027)

p-values in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The coefficients in this table can be interpreted as the elasticity of total loans with respect to the short-term interest rate.

Table 10. Average Elasticities of the Long-term Marginal Effect of Monetary Policy shock with respect to NSFR and LCR shortfalls (Model 1).

Elasticities with respect to					
NSFR shortfall			*LCR shortfall*		
Quartiles of LCR shortfall	Elasticity	p-value	Quartiles of NSFR shortfall	LCR shortfall	p-value
1	-0.176	0.047	1	-0.0007	0.421
2	-0.083	0.099	2	0.018	0.427
3	-0.030	0.050	3	-0.008	0.424
4	-0.020	0.097	4	-0.016	0.441
Total	-0.070	0.072	Total	-0.004	0.429

The coefficients in this table can be interpreted as the percentage change of the long-term marginal effect of a monetary policy shock after a one percent increase in the shortfall.

This table also shows that the impact of changes in the LCR shortfall on the monetary policy shock's long-term marginal effect on loans is not statistically different from zero. This result was expected given that the LCR shortfall coefficient in model 1 is not statistically significant. Nevertheless, under the light of the results of model 2, one would have expected negative elasticities as in the NSFR shortfall case. The same explanations provided above, in the previous sub-section, to bridge the discrepancies between model 1 and 2 results also apply here.

We now turn to the results based on the simulated data. A general conclusion from this counterfactual analysis is that the bank lending channel effectiveness for cooling down the economy is likely to be strongly limited after compliance with the standards. The main results of such analysis are the following. Firstly, big banks are no longer able to cushion monetary policy shocks. Further, even small banks are better prepared after compliance with the standards to shelter a monetary policy tightening. Secondly, while HQLA continues to play a similar role as before compliance, NO tend to help small banks to better cushion the impact of the contractionary shock in monetary policy. In contrast, for bigger banks the sheltering effect is not significant. Finally, effects of the NSFR components (i.e. ASF, RSF) are mostly statistically insignificant.

Our simulations are constrained by one vital point. When simulating the new balance sheet data in order to understand how banks could optimally adjust their balance sheets if they had already adhered to the new Basel III regulations, we took financial innovations as given. However, it is well-known that e.g. securitization was partly a response to capital requirement implementation.[1] It would, clearly, be extremely difficult to predict what kind of financial innovations are likely to occur as a response to Basel III. Additionally, it is nearly impossible to predict how these new financial markets affect existing ones and how this would affect banks' portfolios. Thus, our analysis should be read under the strong assumption that Basel III produces only negligible innovations to the financial sector, or at least only innovations that do not lead to important changes to banks' portfolios. Obviously, whether or not this is a reasonable assumption will be revealed during the next years. Nevertheless, financial innovations tended to be able to shield banks' portfolios more efficiently from monetary policy. Consequently, there is room to believe that our general result would still hold.

[1] We are grateful to one anonymous referee for pointing this out.

Table 11. Estimation results of the growth rate of total loans. Banks' characteristics: LCR and NSFR shortfalls disaggregated

	S1	
Δ ln(loans)$_{t-1}$	-0.117***	(0.0415)
Δi_{t-1}	1.693***	(0.618)
Output-Gap$_{t-1}$	0.352	(0.267)
Size$_{t-1}$	-0.0149	(0.0402)
Size$_{t-1} \cdot \Delta i_{t-1}$	-0.0619***	(0.0239)
NO$_{t-1}$	0.266	(0.364)
NO$_{t-1} \cdot \Delta i_{t-1}$	0.870	(0.801)
Liq.$_{t-1}$	0.0867	(0.187)
Liq.$_{t-1} \cdot \Delta i_{t-1}$	0.269*	(0.158)
Size$_{t-1}\cdot$ NO$_{t-1}\cdot$ Liq.$_{t-1} \cdot \Delta i_{t-1}$	-0.240	(0.149)
Req.Fund.$_{t-1}$	0.176	(0.157)
Req.Fund.$_{t-1}$		
Req.Fund.$_{t-1} \cdot \Delta i_{t-1}$	-0.767**	(0.307)
Av.Fund.$_{t-1}$	-0.0272	(0.0875)
Av.Fund.$_{t-1}$		
Av.Fund.$_{t-1} \cdot \Delta i_{t-1}$	-0.599***	(0.226)
Size$_{t-1}\cdot$ Req.Fund.$_{t-1}\cdot$ Av.Fund.$_{t-1} \cdot \Delta i_{t-1}$	0.0525**	(0.0211)
Obs.	2893	
Hansen, p.v.	0.360	
AR(1), p.v.	0.000	
AR(2), p.v.	0.340	
Groups (Instruments)	144(134)	
Wald, p.v.	0.000	

Estimator: System-GMM. Standard errors in parentheses.

Seasonal and crisis dummies: Yes.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The results confirm the previous statements, namely that the bank lending channel in Luxembourg will potentially disappear. The striking result concerning the ability of small banks to protect their loan portfolio from monetary policy tightening stems from their increase in HQLA which have a positive relationship with the marginal effects, as well as from the reduced burden that adhering to the NSFR imposes on them compared to big banks (see Table 4).

5. Conclusion

In this article we analyzed the role of banks' liquidity risk in the monetary policy transmission mechanism. We did this by estimating the effects of the LCR and NSFR, the Basel III liquidity standards, together with the bank characteristics that have been identified in the literature as being important for monetary policy transmission. These measures allow us to account for the main aspects of liquidity risk in a given period, namely the cash-flows, the amount of unencumbered high-quality liquid assets and the degree of maturity mismatch. Secondly, to the authors' knowledge this study is the first to quantitatively analyze the impact of the new liquidity standards on monetary policy transmission.

The measurement of banks' liquidity risk necessitates highly-granular balance-sheet data which is usually confidential and only available at banking sector supervisory institutions. In order to perform this study we made use of bank-level data collected quarterly by the Central Bank of Luxembourg from 2003q1 to 2010q4. As a result, the empirical results are only valid for countries similar to Luxembourg.

Our results indicate that the LCR and NSFR help identify the bank lending channel. Moreover, in contrast to the findings of studies focusing on other European countries, we find a significant asymmetry between the lending responses to monetary policy shocks of different banks. For instance, the small banks are less able to shelter their loan portfolio from contractionary monetary policy shocks. Conversely, banks with higher ratios of High Quality Liquid Assets (top chip marketable securities) and of Available Stable Funding (essentially composed of liabilities with maturity greater than one year) show a greater ability to absorb monetary policy shocks. In contrast, banks with higher Net Outflows (short-term funds or from unstable sources) and/or Required Stable Funding ratios (essentially composed of illiquid claims or with maturity greater than one year) tend to be less prepared to deal with monetary policy shocks. Overall, we conclude that the bank lending channel mainly works through small banks with a large shortfall in the NSFR.

The second novelty in the paper is the estimation of the effect of banks' compliance with Basel III liquidity standards on monetary policy transmission. The results of the analysis suggest that complying with the NSFR will significantly reduce the relevance of the bank lending channel as it has just been identified in this paper for the Luxembourg case. Conversely, complying with the LCR does not have a significant impact. The intuition is straight-forward since a bank can 'trade' the LCR shortfall by borrowing short term (i.e. increasing the NO) in order to fund a higher stock of HQLA. This allows banks to improve their LCR position and generates a positive correlation between the two components of the ratio. Consequently, the LCR shortfall might be bereft of statistical significance.

One can argue that complying with the new liquidity regulations might potentially modify the channel of monetary policy transmission. Then, by adopting a counterfactual approach we further analyze the potential modifications that complying with the new standards would introduce to the bank lending channel of monetary policy transmission. With this aim, we estimate a set of models based on the simulated bank level data. The results of the counterfactual analysis confirm previous conclusions, namely the bank lending channel in Luxembourg would tend to be less effective for cooling down the economy.

The introduction of the Basel III liquidity regulations in Luxembourg is, therefore, likely to lead to a banking sector that is, on the one hand, more resilient to crises but, on the other hand, also less likely to react to monetary policy shocks.

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