4 MARKET AND FUNDING SYSTEMIC LIQUIDITY STRESS TESTING OF THE LUXEMBOURG BANKING SECTOR

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1 MOTIVATION

The peculiarities of the current crisis have motivated a wide-spread rethinking of modern financial, monetary and supervisory frameworks. From accounting rules to the operation of rating agencies; from the role of central banks and their objectives to the basic paradigm of prudential supervision; academic research, working groups, and high level meetings have started to set the pillars of new institutions and market practices to minimize the risk of future similar crises.

One major policy message from the crisis is the need to develop the macroprudential element of financial stability policy. It is now generally accepted that microprudential regulation and supervision of individual institutions and markets, while necessary, is not sufficient, because it does not consider the interactions among financial institutions and between the financial system and the real sector of the economy. For macroprudential policy to minimize the risk that financial instability would result in broader costs to the economy, it needs to develop quantitative macroprudential operating targets to measure and monitor the main determinants of systemic risk, both in its time series dimension (e.g., countercyclical capital charges) and in its cross-section dimension (e.g., interbank lending concentration limits) (Borio and Drehmann, 2009). As a result, a number of macroprudential instruments are already in use or under consideration.

Macro stress tests belong to the set of operating instruments that have been used by central banks and supervisors to trace the response of the financial system to severe, but plausible shocks. While forward-looking in their nature, they have suffered from the failure to capture in a robust way the feedback effects between the financial system and the macroeconomy, and to capture a key aspect of financial distress, namely, the nonlinearities responsible for the large systemic effects of small shocks (Drehmann, 2009). In a cross-section dimension, stress tests have incorporated the interactions between institutions, markets and infrastructure to study how these contribute to the vulnerabilities of the financial system. However, it was not until well into 2007 that it became clear that a top priority for financial stability is to strengthen the understanding of the role of interconnectedness among financial institutions, of common exposures to risks, of the endogeneity of agents' responses, of the conditionality of parameters on stress events, and other significant systemic features.

One peculiarity of the current financial crisis has been the seizing up of the interbank market. This dramatically revealed the endogeneity of liquidity in a fiat-currency economy and the ensuing need to take into account liquidity risk in stress testing exercises of the banking system. Rapid changes to endogenous liquidity can quickly reverberate through the financial system and exhaust banks' liquidity buffers via asset price changes, drying up of liquidity lines, and paralysis of the interbank market as a result of large increases in counterparty risk and uncertainty. Liquidity stress testing has become an essential part of IMF Financial Sector Assessment Programs since 2001: tests have assumed shocks to deposits, to wholesale funding, and also used cross-border scenarios (Moretti et al, 2008). However, stress-testing models used by monetary authorities and supervisors have not often made clear the systemic implications of liquidity shocks and the intrinsic relation between counterparty credit risk, funding and market liquidity (IMF, 2008).[1]

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1 According to the Basel Committee on Banking Supervision (BCBS) (2008), market liquidity risk is "the risk that a firm cannot easily offset or eliminate a position at the market price because of inadequate market depth or market disruption". According to the BCBS, funding liquidity risk is the risk that a bank will be impaired in its "ability to fund increases in assets and meet obligations as they come due" and "at a reasonable cost". Similar definitions are in Brunnermeier and Pedersen (2009).

Further weaknesses of current stress testing practices can be highlighted. First, in most available stress testing exercises and contingency funding plans, banks do not consider the feedback effect of their behaviour on the price of assets or on their reputation when they take action to recover their desirable liquidity buffers. During the current crisis, some banks did experience difficulties in selling assets or pledging assets in secured lending (ECB, 2008). Second, given the existence of (risk unrelated) deposit insurance and the history of central bank intervention to provide sufficient liquidity during crises, moral hazard considerations suggest that banks hold suboptimal levels of liquidity. Overall, liquidity risk is underpriced and the crisis has made clear that it was excessive. Finally, additional enhancements include incorporating off-balance sheet risks in liquidity stress testing, covering cross-border transmission channels, modelling the behavioural responses of agents, and adding non-bank financial institutions. Looking forward, enhanced frameworks for systemic liquidity stress testing will be a crucial instrument in fulfilling the macroprudential tasks of international bodies such as the ESRB.

In Luxembourg, the Law of 24 October, 2008, made the Banque centrale du Luxembourg (BCL) responsible for the surveillance of the general liquidity situation on the markets and for evaluating financial market operators. As a result, the BCL has been building a series of tools to assess the general liquidity of the market and market participants. Rychtarik (2009) develops an approach to measure the liquidity risk sensitivity of Luxembourg banks from the viewpoint of the impact of shocks on banks' liquidity ratios, in order to identify the most severe scenario (or combination of scenarios) and the most vulnerable banks in the system. Rychtarik and Stragiotti (2009) describe the liquidity position of Luxembourg banks using two different scores, (1) across "peer" banks, and (2) over time, and use them to draw conclusions on trends within the Luxembourg banking sector as a supervisory tool.

The present study represents a natural follow up of work on liquidity risk at the BCL. The framework used in this study draws on the model developed at the De Nederlandsche Bank by J.W. van den End (2008), adapted to take into account Luxembourg idiosyncrasies.[2] The model takes a stochastic approach to systemic liquidity stress testing, while being fully compatible with, and operational for, analyzing bank-level liquidity risk as well (as required by the Law of 2008). It focuses on the effects of market and funding liquidity risk on banks' liquidity buffers; uses industry and ECB-determined haircuts and run-off rates and accounts for uncertainty via Monte Carlo simulations using a log-normal distribution; includes banks' reactions to the shock and; the possibility of a drying-up of funding from cross-border parent banks. In a follow-up paper, second–round, feedback effects due to joint banks' reactions on asset prices and banks' reputation are taken up. Section II discusses the data, haircuts and run-off rates. Section III explains the results of the model simulations. Section IV concludes.

2 DATA, HAIRCUTS AND RUN-OFF RATES

Consistent with the literature on stress testing, the composition and measurement of the liquidity buffer plays a central role in this study (ECB 2008, BIS 2009a). First, the quarterly database used in this study covers 52 banks during the period 2006q1-2009q3; as of 2009q3, the sample represented nearly 90 percent of total bank assets. Second, items of the liquidity buffer are evaluated according to a set of haircuts applicable to each type of financial instrument and featuring the same economic characteristics. Importantly, measurement of assets included in the buffer acknowledges that the same kind of asset may enjoy different liquidity characteristics depending on the currency of denomination, an illustration of a Luxembourg peculiarity of the model.[3]

2 We thank Jan Willem van den End for his valuable assistance and cooperation in this study.

3 The model is flexible enough to be used for an exchange rate shock, but this is not shown here.

The liquidity buffer is a portfolio of high quality, highly liquid unencumbered securities as defined in the BIS guidelines (2009b); those guidelines are also followed for the definition of the haircuts and run-off rates (Tables 1 and 2).[4] As a result, several components of banks' portfolios are withdrawn, such as unlisted stocks and shareholding participations. The most significant off-balance sheet items included are committed credit lines.

Table 1 :

Liquidity buffer: haircuts applied to selected balance sheet items[1)]

TYPE OF BS ITEM	TYPE OF ISSUER	CURRENCY OF ISSUANCE	COUNTRY OF ISSUANCE	RESIDUAL MATURITY - HAIRCUTS			
				<1 year	1<year<2	year>2	unspecified
Listed stocks		EUR	EURO AREA	n/a	n/a	n/a	50%
		USD	US	n/a	n/a	n/a	50%
		JPY	JAPAN	n/a	n/a	n/a	50%
		AAA FOREIGN CCY RATING	AAA FOREIGN CCY RATING	n/a	n/a	n/a	50%
		EUR	EURO AREA	n/a	n/a	n/a	50%
		USD	US	n/a	n/a	n/a	50%
		JPY	JAPAN	n/a	n/a	n/a	50%
		AAA FOREIGN CCY RATING	AAA FOREIGN CCY RATING	n/a	n/a	n/a	50%
Debt financial instruments	Credit institution	EUR	EURO AREA	20%	30%	40%	50%
			G10 (NON EEA)	30%	40%	50%	60%
			EEA (NO EURO AREA)	40%	50%	60%	70%
		USD	EURO AREA	30%	40%	50%	60%
			G10 (NON EEA)	40%	50%	60%	70%
			EEA (NO EURO AREA)	50%	60%	70%	80%
		JPY	EURO AREA	30%	40%	50%	60%
			G10 (NON EEA)	40%	50%	60%	70%
			EEA (NO EURO AREA)	50%	60%	70%	80%
		AAA FOREIGN CCY RATING	EURO AREA	50%	60%	70%	80%
			G10 (NON EEA)	60%	70%	80%	90%
Debt financial instruments	Non financial institutions	EUR	EURO AREA	40%	50%	60%	70%
			G10 (NON EEA)	50%	60%	70%	80%
			EEA (NO EURO AREA)	60%	70%	80%	90%
		USD	EURO AREA	50%	60%	70%	80%
			G10 (NON EEA)	60%	70%	80%	90%
			EEA (NO EURO AREA)	70%	80%	90%	100%
		JPY	EURO AREA	50%	60%	70%	80%
			G10 (NON EEA)	60%	70%	80%	90%
			EEA (NO EURO AREA)	70%	80%	90%	100%
		AAA FOREIGN CCY RATING	EURO AREA	70%	80%	90%	100%
			G10 (NON EEA)	80%	90%	100%	100%

4 Available unencumbered assets are marketable as collateral in secondary markets and/or eligible for central banks' standing facilities.

TYPE OF BS ITEM	TYPE OF ISSUER	CURRENCY OF ISSUANCE	COUNTRY OF ISSUANCE	RESIDUAL MATURITY - HAIRCUTS			
				<1 year	1<year<2	year>2	unspecified
Debt financial instruments	Government	EUR	EURO AREA	2.5%	5.0%	7.5%	10.0%
			G10 (NON EEA)	5.0%	7.5%	10.0%	12.5%
			EEA (NO EURO AREA)	7.5%	10.0%	12.5%	15.0%
			X1	70.0%	80.0%	90.0%	100.0%
		USD	EURO AREA	5.0%	7.5%	10.0%	12.5%
			G10 (NON EEA)	7.5%	10.0%	12.5%	15.0%
			EEA (NO EURO AREA)	10.0%	12.5%	15.0%	17.5%
			X1	80.0%	90.0%	100.0%	100.0%
		JPY	EURO AREA	5.0%	7.5%	10.0%	12.5%
			G10 (NON EEA)	7.5%	10.0%	12.5%	15.0%
			EEA (NO EURO AREA)	10.0%	12.5%	15.0%	17.5%
			X1	80.0%	90.0%	100.0%	100.0%
		AAA FOREIGN CCY RATING	EURO AREA	7.5%	10.0%	12.5%	15.0%
			G10 (NON EEA)	10.0%	12.5%	15.0%	17.5%
			EEA (NO EURO AREA)	12.5%	15.0%	17.5%	20.0%
			X1	90.0%	100.0%	100.0%	100.0%
Money market funds	Credit institution	EUR	EURO AREA	n/a	n/a	n/a	50%
		USD	US	n/a	n/a	n/a	60%
		JPY	JAPAN	n/a	n/a	n/a	60%
		AAA FOREIGN CCY RATING	AAA FOREIGN CCY RATING	n/a	n/a	n/a	70%
Cash	All sectors	All currencies	All countries	0%	0%	0%	0%

1) Derivatives are not included in the buffer at this stage.

The BCL database used for this study encompasses several dimensions. They are the type of balance sheet item (e.g., listed shares, cash), the type of counterparty (e.g., holding companies, international organizations), the country of origin of the counterparty (e.g., non Eurozone countries, AAA-rated foreign countries), and the currency of issuance of financial instruments. Residual maturities are used whenever available.

Haircuts are based on banks' practice in Luxembourg (Rychtarik, 2009, Rychtarik and Stragiotti, 2009), industry standards (Standard & Poor's, 2007), ECB requirements (ECB, 2006), and judgement. The study emphasizes the importance of information regarding geopolitical and macroeconomic data. The country of origin and the currency of each financial instrument play a significant role in haircuts' evaluations. However, given that the available database does not discriminate across types of securities (e.g., callable bonds versus bonds held to maturity), simplifications are necessary.

A haircut does not depend always on the *type* of security. For instance, no distinction is made between the haircuts of asset-backed securities and corporate bonds issued in the same currency by the same type of entity, in the same country. This issue becomes somehow less relevant if put in the context of the approach taken, which is partly inspired by the ECB implementation of monetary policy operations. Indeed, for the latter, the *type* of financial instrument becomes less relevant regarding the eligibility criteria.

The BCL database distinguishes four types of *maturities*. In this context, several hypotheses have to be made. It is not feasible to distinguish across different securities based on their maturities. For example, within the category of debt instruments with a maturity below 1 year, it is not possible to determine what amount represents commercial paper and what amount represents other financial instruments.

The same framework supports the determination of run-off rates. These rates are set to reflect several facets of potential liquidity shocks of systemic and idiosyncratic nature. The run-off rates are based on the historical observation of past shocks in the Luxembourg banking sector; literature references and; (3) information received from surveys of Luxembourg banks.[5]

Table 2:

Run-off rates applied to selected stressed balance sheet items

TYPE OF BS ITEM	TYPE OF ISSUER	CURRENCY OF ISSUANCE	COUNTRY OF ISSUANCE	RESIDUAL MATURITY - RUN-OFF RATES			
				<1 year	1<year<2	year>2	unspecified
Liabilities							
Deposits - retail - Luxembourg		all currencies	all geopolitical areas	n/a	n/a	n/a	20%
Deposits - retail - non Luxembourg		all currencies	all geopolitical areas	n/a	n/a	n/a	20%
Deposits - corporate - all		all currencies	all geopolitical areas	n/a	n/a	n/a	50%
Deposits - banks - non Related Parties		all currencies	all geopolitical areas	n/a	n/a	n/a	65%
Fiduciary deposits - banks 1Y		all currencies	all geopolitical areas	n/a	n/a	n/a	90%

TYPE OF BS ITEM	TYPE OF ISSUER	CURRENCY OF ISSUANCE	COUNTRY OF ISSUANCE	RESIDUAL MATURITY - HAIRCUTS			
				<1 year	1<year<2	year>2	unspecified
Assets							
Interbank deposits	Credit institution	all currencies	EURO AREA	10%	30%	50%	70%
			G10 (NON EEA)	20%	40%	60%	80%
			EEA (NO EURO AREA)	20%	40%	60%	80%

1) The table does not discriminate by type of deposit (in terms of their residual maturity). Local liquidity risk managers suggest that from a liquidity perspective, the type of deposit (e.g., demand versus time deposit) does not play a crucial role in determining the behaviors, and therefore the run-off rates of banks' clients.

The framework used for haircuts and run-off rates is, however, only an operational reasonable starting point. A major weakness of stress testing models has been the use of historic data for haircuts and run-off rates given that realized elasticities under stress conditions are, most likely, going to be quite different. Therefore, this study applies a stochastic approach.

5 Money market funds' deposits are excluded from the table because they are held mostly, albeit not exclusively, by custodian banks. The practice of these banks in Luxembourg seems to exclude these funds from their maturity transformation activity. The BCL database does not allow a distinction between custodian and non-custodian banks (Rychtarik and Stragiotti, 2009, take a different approach, not followed in this paper, and assume as scenario a potential withdrawal of deposits from funds). Note that run-off rates do not refer to intraday liquidity risk, the risk custodian banks face.

Box 1:

SIMULATIONS

Liquidity buffers are made stochastic to overcome, at least partly, not only the short-supply of stress-situations data and their limited value, but also the possibility of rapid changes in asset values, and the uncertainty in the model parameters and banks' reaction functions. Monte Carlo simulations of haircuts and run-off rates are performed by taking 50,000 draws from a log-normal distribution. The use of this distribution is consistent with the nonlinearities of extreme liquidity stress occurrences and risk management practice. In the simulations, the distribution is adjusted to reflect tail events, or three standard deviations. Therefore, the log normal distribution used is Exp ((N(0,1)*(weights(i)/3)). Like in van den End (2008), shocks are simulated by stressing the haircuts and run-off rates; this is the first stage of the exercise. Given the granularity of balance and off-balance sheet information used, shocks can be implemented in a flexible way. Banks' reactions to mitigate the impact of the shocks on their liquidity buffers constitute the second stage. If banks' reactions are quite generalized and similar, or if they are the result of large institutions' actions, they may have systemic consequences in the form of falls in asset prices, increased margins calls, and more expensive funding. This, together with additional losses as a result of the interaction between liquidity risk and credit risk or to reputational effects, constitutes the third stage of the model. This third stage is implemented in a forthcoming paper.

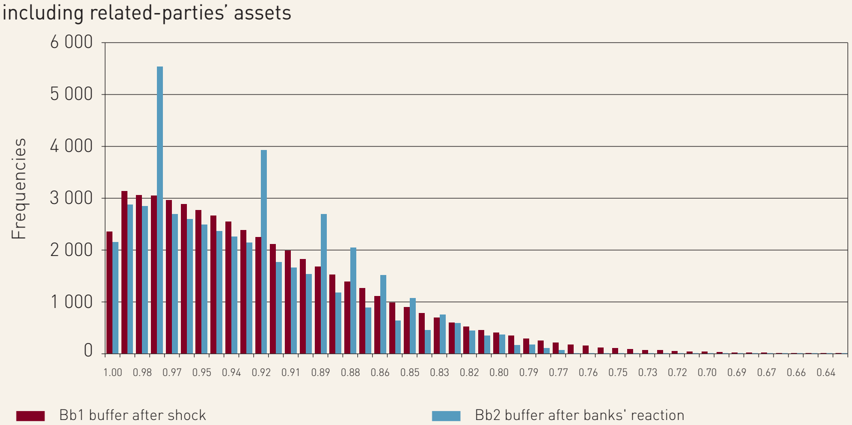
3 SIMULATION RESULTS

The stress testing exercise covers market and funding liquidity risk. The following shocks are used to test the resilience of the Luxembourg banking sector. First, a systemic *shock to interbank loans* is assumed to affect the whole banking sector. The entire stock of interbank loans undergoes a severe, albeit plausible stress. Second, *interbank loans* granted by Luxembourg banks are shocked. In this scenario, each bank suffers a loss proportionate to the share of its interbank loans. Third, a severe, simultaneous run-off of retail *deposits* of resident and non-resident clients, corporate deposits, non-related parties interbank deposits, and fiduciary deposits is instrumented. Finally, a shock affecting the *related entities' deposits* is simulated.

First shock: systemic shock to interbank loans

In the first shock, each bank loses part of the value of its interbank loans. The magnitude of the loss is set by the simulated run-off rates. The shock hits all the banks carrying this type of exposure. In the case of this shock, the interest is not in the outcome for individual banks, but rather for the banking sector as a whole (Figure 1).

Figure 1
Systemic shock to interbank deposits: shock and banks' responses, including related-parties' assets



The chart displays the impact of the systemic shock on banks' buffers *(Bb1)* standardized by the baseline liquidity buffer *(Bb0)*; *Bb1* buffers are calculated by subtracting from the baseline buffer, the first-round effects of the shock. The abscissa shows the remaining share of the buffer of the whole banking sector. The ordinate displays the corresponding frequencies. The largest potential loss incurred by the Luxembourg banking sector after the occurrence of an interbank shock would be around 36 percent of the baseline buffer *Bb0*.[6] *Bb2* describes the buffers' distribution after the banking sector takes mitigating actions following the initial shock.[7] The *Bb2* buffer is, therefore, the result of adding to the set of buffers *Bb1*, the transactions performed by banks as shock mitigating actions.[8] After its reaction, the banking sector is better off and is expected to be left in a worse case scenario with roughly 77 percent *(Bb2)* of its baseline buffer. This implies a potential loss of about 23 percent.[9] Moreover, the associated frequencies indicate that the recovery is in general more likely.

Figure 2
Systemic shock to interbank deposits: shock and banks' responses, excluding related parties

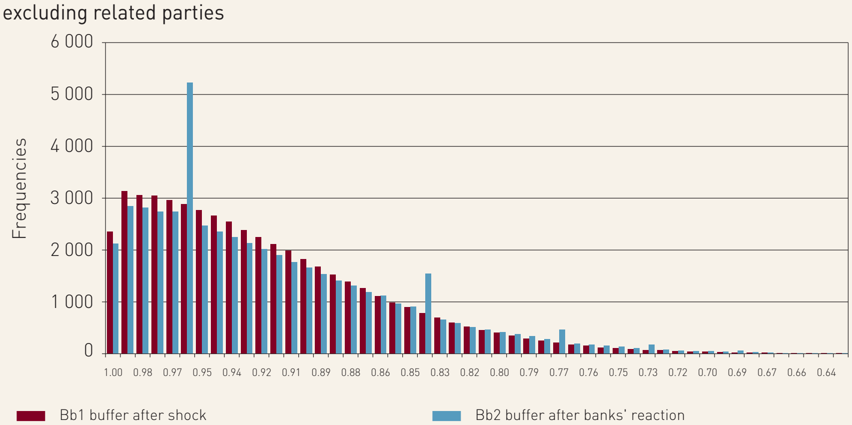


Figure 2 illustrates the response of the banking sector, excluding related parties' deposits. The profile of *Bb2* changes substantially. The likelihood of the banking sector incurring a severe loss increases; in *Bb2*, the largest potential loss rises to roughly 33 percent, from 23 percent. Moreover, the associated frequencies are lower than in the previous case, displayed in Graphique 9. These results highlight the critical role of related parties in the local banking sector.

Second shock: interbank deposits shock, excluding related parties

This shock is different from the previous one in that it emphasizes individual bank's outcomes. The exercise has systemic relevance in that it makes it clear that banks' business lines and banks' interactions, as they are quite diverse in Luxembourg, should be taken into account in assessing the effects of liquidity shocks. In order to illustrate the relevance of those banks' characteristics, five banks are selected according to their relative importance in the Luxembourg banking sector and their business profile. The choice of the selected banks covers most of the spectrum of the current businesses run by Luxembourg banks. Figure 3 shows the results of the interbank shock on three of the banks' buffers distributions.

6 Most Luxembourg banks are subsidiaries or branches of foreign banking groups and play an important role in the financing of the group. Their major source of financing is the interbank market. Interbank liabilities represent about 50 percent of total liabilities, of which three quarters are intra-group.

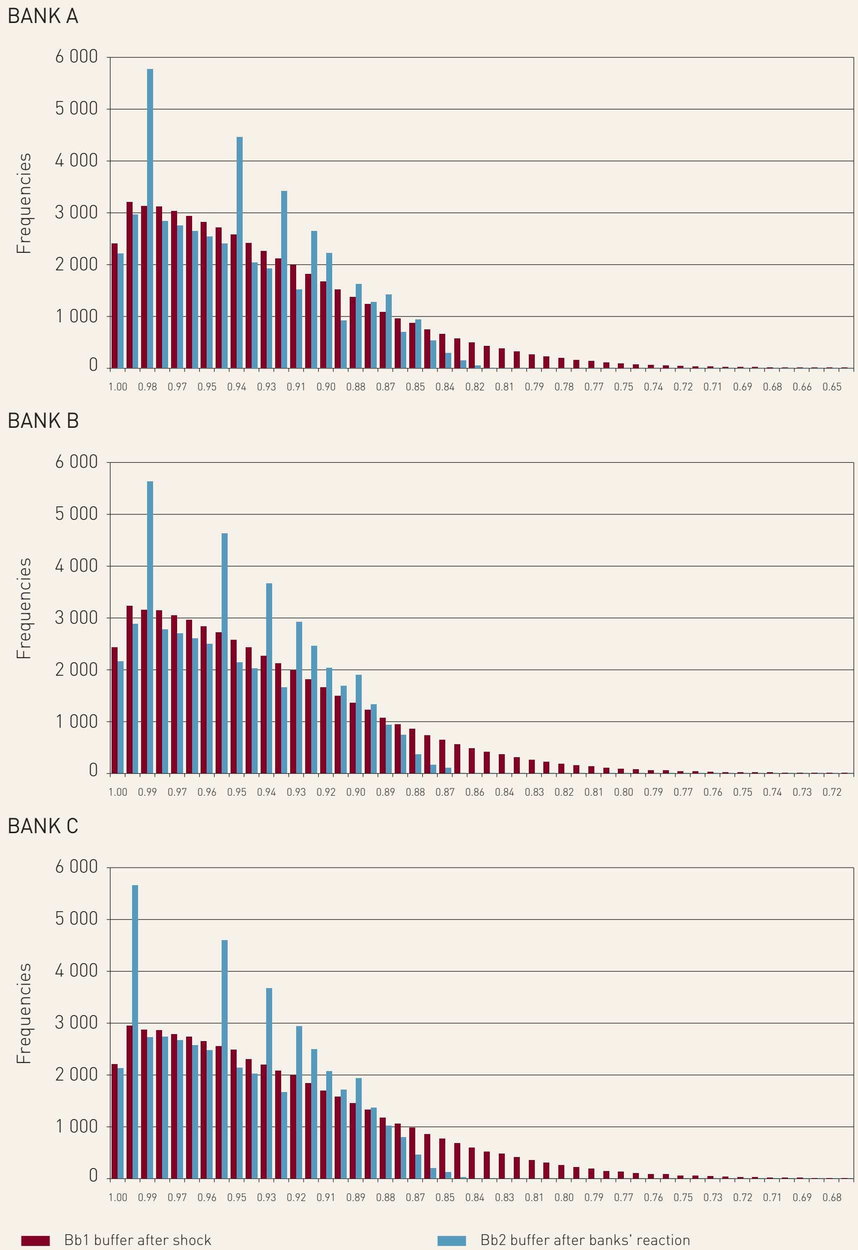
7 Only banks suffering at least a 30 percent loss of their baseline buffers are supposed to react; they represent 71 percent of the sample. The 30 percent threshold was estimated regressing the ranking of the contemporaneous changes in the baseline buffer as a result of the (interbank) shock on the ranking of changes in the balance sheet items for a rho Spearman correlation coefficient at the 99 percent confidence level. This is used as a proxy for the lack of knowledge of banks' risk tolerance levels.

8 Banks are supposed to react, for example, by using securities for repo operations with the central bank, by selling securities, or funding themselves in the unsecured interbank market. Absent a micro-foundation of banks' reactions, as in van den End (2008), the extent to which banks use a particular item of their portfolio to restore the baseline liquidity buffer is determined by the relative importance of the item in the balance sheet, which is obviously a reflection of each bank's business line.

9 As a reference, in the DNB liquidity stress testing exercise of Dutch banks, the baseline buffer loss following a credit shock is 40 basis points and following a banking crisis is about 1.1 percent.

Bank A is mostly a retail bank with important interbank volumes on the assets' side which represent about 38 percent of its baseline buffer. Bank B is active in several business lines (notably retail, custody and corporate); its interbank-buffer ratio is 30 percent. Bank C is mainly a global custodian bank, active in the field of services to investors with an interbank-buffer ratio of 33 percent. Bank A experiences the largest potential impact following the interbank shock. Indeed, its expected buffer in a worse case scenario would be roughly 65 percent of its baseline buffer.[10] Taking remedial actions, bank A would recover roughly 20 percentage points of its baseline buffer loss. Bank B and C are less affected by the interbank shock as they are expected to maintain 70 percent and 67 percent of their baseline buffers, respectively, after the shock. After reacting, bank B would recover roughly 18 percentage points of its baseline buffer loss, and bank C would recover 20 percentage points of its baseline buffer loss. Differences across banks can be explained by the different composition of their portfolios, and therefore, their corresponding simulated haircuts.

Figure 3
Interbank shock: shock and individual banks' responses



Third shock: a run on deposits, excluding related parties

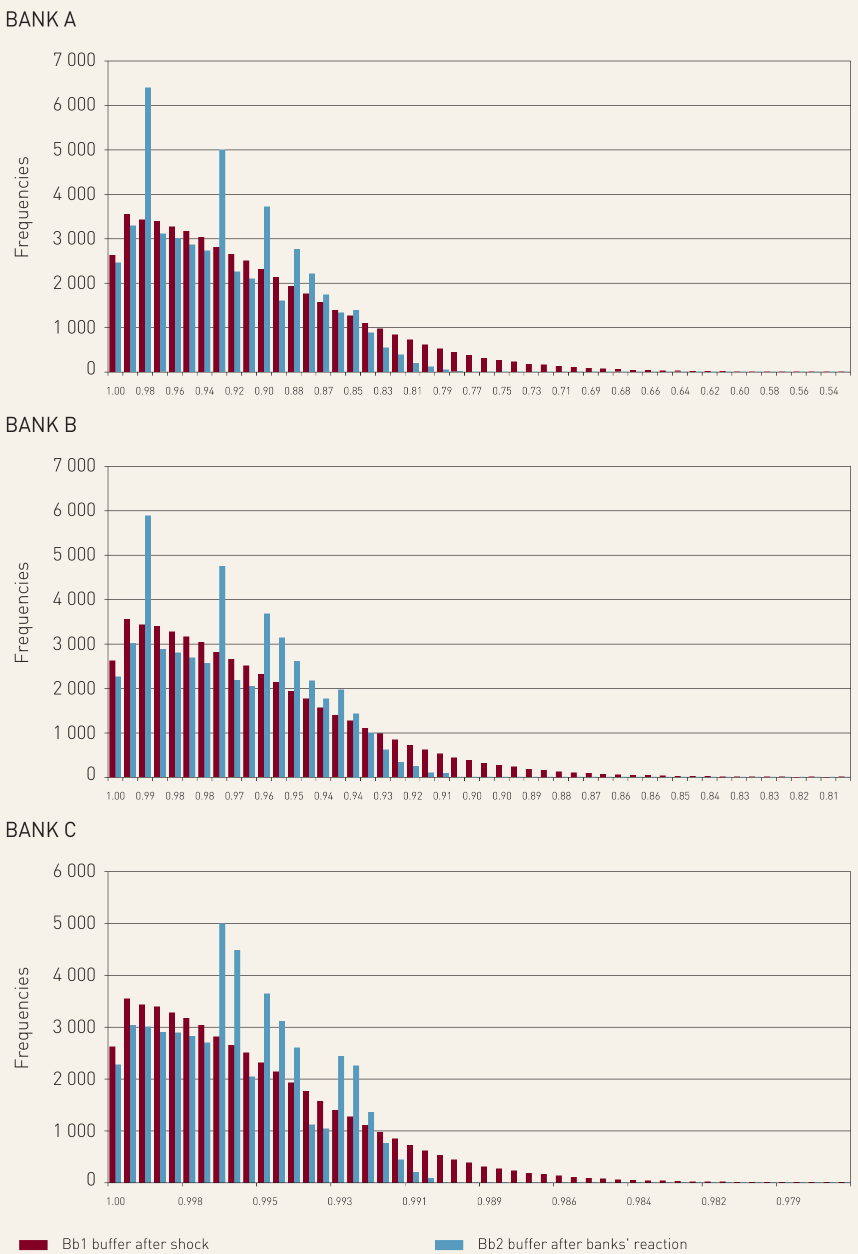
The shock on deposits is a very severe event for bank A and a moderately severe event for bank B; this is the result of the fact that both banks rely on funding from retail and corporate clients. The shares of deposits shocked represent 88 percent and 37 percent of bank A's and bank B's baseline buffers, respectively.[11] In contrast, bank C deposits account for 2 percent of its baseline buffer and the shock's effects are correspondingly really minor. These results are shown in Figure 4.

10 Small losses at the extreme of the distribution are not always visible on the charts due to scaling reasons. The discussion in the text, however, takes these results into account.

11 The main difference between these two banks is the large amount of related-party deposits in bank B.

The shock on bank A's deposits has an important impact on its buffer. Bank A is expected to lose potentially up to 47 percent of its liquidity buffer after the shock. The bank's response improves its buffer allowing it to recover 30 percentage points of its baseline buffer. Although banks B and C do not lose up to 30 percent of their baseline buffers—especially bank C—their reactions are shown here for illustrative purposes. Bank B, whose largest potential loss equals 19 percent of its baseline buffer, has quite a different profile from bank A. Following the bank's mitigating actions, bank B recovers up to 13 percentage points of its baseline buffer. Bank C is less affected by the shock: the expected loss amounts to roughly just 2 percent of Bb0. Accordingly, the bank can face this shock without undergoing a severe stress, and if it were to take mitigating actions, it would recover almost its whole initial buffer.

Figure 4
Run-on-deposits shock: shock and banks' responses

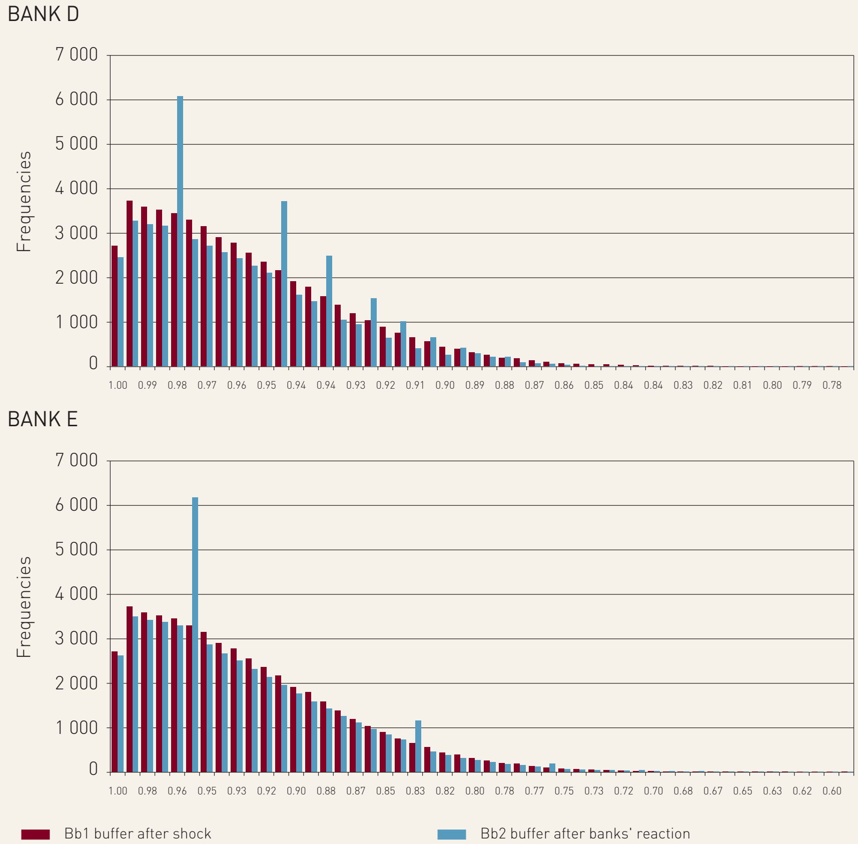


Fourth shock: related parties' withdrawal shock

Given that well over one-third of Luxembourg banks' liabilities are intragroup, this shock is very relevant to assess the survival capacity of Luxembourg banks. In this scenario, related entities withdraw their deposits, an important share of Luxembourg banks' funding. The shock is run on the remaining two, out of the five banks selected. Figure 5 illustrates the effects of this shock. The two selected banks are bank D, with related-parties' deposits representing 22 percent of its baseline buffer, and bank E, with related-parties deposits representing 55 percent of its buffer.

This shock potentially accounts for a loss of 22 percent of bank D's baseline buffer and 40 percent of bank E's.[12] On average, banks' reactions do not allow the banks to recover much of the loss incurred during the shock. Bank D can recover about 8 percentage points of its initial loss and bank E can recover just 3 percentage points. These results show the potentially severe impact that the withdrawal of intragroup positions of Luxembourg banks can have.

Figure 5
Related-parties withdrawal shock: shock and distribution of banks' responses



4 CONCLUSIONS AND POLICY IMPLICATIONS

The results of the liquidity stress testing exercise highlight the systemic relevance of deposits from related parties in the reaction of banks to a shock to interbank loans. The Luxembourg banking sector's largest potential loss becomes 10 percentage points lower if related parties' interbank deposits are included in the reaction of the banks (first shock). Accordingly, banks' likelihood of recovering the baseline buffer increases considerably. The importance of related parties' deposits evinces clearly as well in the case of the related-parties' withdrawal shock (fourth shock). In particular, one of the banks investigated in relation with this shock hardly recovers any buffer loss following its reaction to this event.

In general, it seems that both the business model and the composition of the buffer play a role in determining the profile of the simulated shocks. Indeed, banks' reactions to an interbank shock are more effective than banks' reactions to a non-bank deposit run in order to restore, at least partially, their baseline liquidity buffers. The results of the study stress also the apparent lesser relevance of a "run on the bank" scenario for the observed banks. This may be caused by the characteristics of the local banking sector, populated by several banks active simultaneously in several business lines, and thus more diversified, which makes them more resilient to a specific shock.

Given that the paper includes the liquidity shocks and banks' reactions to mitigate the effects of the shocks on their baseline liquidity buffers (first round effects), a natural follow-up is to also consider the endogenous effects on banks' buffers following banks' collective actions, and their impact on asset prices and banks' reputation (second round effects). Those simulations will be covered in a forthcoming study.

12 Bank D's results are shown for illustrative purposes as the shock would not prompt a bank's reaction given that the shock does not reduce its baseline buffer beyond the 30 percent threshold.

Yet, even before considering the simulations for second round effects, the results indicate the importance of system-wide measures to minimize the systemic effects of liquidity shocks, both ex-ante and ex-post, such as sound liquidity management frameworks and contingency plans, robust liquidity buffers, and deposit insurance. This study is, therefore, one more important macroprudential tool which Luxembourg can use to incorporate financial stability considerations into monetary policy decision-making. It provides a framework to produce quantitative judgments on systemic risk and financial stability.

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