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LIQUIDITY SCENARIO ANALYSIS IN THE LUXEMBOURG BANKING SECTOR

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Contents

Liquidity scenario analysis in the Luxembourg banking sector*

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Abstract

This paper aims to develop the basis for an approach to measure the liquidity risk sensitivity of banks in Luxembourg and to test it on real banking sector data. For this purpose we have developed four different scenarios: run on a bank, use of committed loans by counterparties, netting of the position with the parent financial group and changes in conditions of refinancing operations with the Eurosystem. The impact of all four simulations is measured by relative changes of liquidity ratios that have been introduced for this purpose. In a second step, this methodology is tested on a sample of 32 banks active in the Luxembourg banking sector aiming at identifying the most severe scenario or a combination of scenarios and the most vulnerable banks of the sample.

Keywords: Liquidity risk, Scenario analysis, Banking sector, Stress testing.

JEL classification: G21

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Résumé non-technique

Dans cette étude nous avons essayé de développer une méthodologie susceptible de qualifier le risque de liquidité et de l'appliquer au système bancaire luxembourgeois. Compte tenu de la dynamique qui caractérise le risque de liquidité, notre approche consiste en une analyse par scénarios.

Dans un premier temps, nous avons introduit quatre ratios de liquidité qui reflètent la diversité des activités bancaires, mais aussi l'hétérogénéité des facteurs sous-jacents au risque de liquidité et propres au secteur bancaire luxembourgeois. Ces ratios couvrent le risque résultant de plusieurs sources, notamment le volume et la composition des actifs liquides, la volatilité des dépôts des ménages, des entreprises et des fonds d'investissement, la structure et l'ampleur des activités hors-bilan et enfin, la transformation des échéances entre les actifs et les passifs. Nous avons développé ensuite quatre scénarios de stress. Les deux premiers peuvent être qualifiés de standard : Il s'agit d'une part de la ruée sur les dépôts bancaires traduite par un retrait massif de dépôts et d'autre part de la matérialisation des engagements de prêt octroyés et qui sont renseignés au hors-bilan. Le troisième scénario reflète le caractère « *host* » du secteur bancaire luxembourgeois étant donné que la majorité des établissements de crédit sont des succursales ou des filiales de groupes financiers étrangers. Afin de mieux appréhender le rôle de l'entité luxembourgeoise dans la gestion de la liquidité du groupe financier, ce scénario simule une compensation (« *netting* ») des positions (bilan et hors-bilan) avec les parties liées. Le dernier scénario est axé sur les abattements appliqués aux différents types de titres de créance dans le calcul des actifs liquides. Pour qualifier l'impact des scénarios, les valeurs des ratios de liquidité en temps normal sont comparées aux valeurs résultant des scénarios.

Dans un deuxième temps, cette méthodologie est appliquée à un échantillon de trente-deux établissements de crédit établis au Luxembourg. La taille de l'échantillon est susceptible de représenter la diversité du secteur bancaire luxembourgeois d'un point de vue activités, propriété et profil de risque. Sur base de cet échantillon, nous avons essayé d'identifier le scénario de stress le plus sévère, la combinaison des scénarios la plus sévère ainsi que la banque la plus exposée au risque de liquidité compte-tenu de l'ensemble des scénarios.

1 Introduction

Current market developments have shown that the liquidity risk is one of the most complex issues in financial markets. While we are usually fully aware of the practical difference between liquidity risk and other banking risks (e.g. credit, market or operational risk) notably in terms of understanding these risks as a potential impact on bank's capital, we often forget about the basic conceptual difference. Unlike credit or market risk, which is implicit to many business activities also outside the financial world, the liquidity risk in the banking industry is very much related to our monetary model with fractional reserves and to the role that banks are expected to play as financial intermediaries. However, banks primarily understand the problem of liquidity as one of the financial risks they are facing. As a result, liquidity is both a micro-prudential and macro-prudential issue, and as such both a supervisory and a central bank concern. Furthermore, policy decisions about liquidity are usually difficult as the objectives of prudential banking and economic growth are not necessarily aligned.

In our paper we focus only on the micro-prudential aspect of liquidity risk. The aim of the paper is to develop a simple methodology which would improve our insight into the liquidity positions of credit institutions in the Luxembourg banking sector and which could also be relevant for some other banking sectors that share some similar features (e.g. importance of foreign subsidiaries and branches).

According to the Banque centrale du Luxembourg (2008), the liquidity indicators analysed at the aggregated level of the banking sector were favourable, while the liquidity conditions continued to be rather difficult. Such combination calls for further investigation.

The methodology is tested on a sample of 32 banks active in the Luxembourg banking sector. In a first step, an analysis of the change of different liquidity ratios is presented, based on the respective scenarios. In a second step, the results are aggregated in order to identify the most severe scenario or a combination of scenarios and to identify the most vulnerable banks of the sample.

2 Methodology

Most publications related to liquidity focus on macro issues rather than on stress tests of individual banks. For example, Harrison (2002) investigates the impact of liquidity shocks on the composition of firms that enter the corporate bond market or Wong et al (2002), which investigate the Hong Kong stock market and its evolution since the Asian financial crisis, while examining the determinants of changes in liquidity. Both papers are related to this work through our approach as regards the definition of "liquid assets". However, they are not directly applicable, as they deal primarily with market liquidity.

Being aware of the complex and dynamic nature of liquidity risk, we have opted for a simplified scenario based analysis. We have introduced four ratios, which reflect the liquidity position of 32 Luxembourg banks. Based on these ratios we measure the impact of a stress situation as a relative change to the baseline values of these ratios.

A similar approach is also used by Boss et al (2004) where the liquidity ratio is stressed based on the reported residual time to maturity structure of banks' assets and liabilities or by Jurca et al (2006) where the stress test was not applied to capital adequacy but to three selected liquidity indicators. Such an approach prevents us from drawing strong conclusions based on too many assumptions and allows us to interpret the liquidity risk as a relative and behavioural issue. This means that a negative change in liquidity ratios should be interpreted as an increase in liquidity risk but not necessarily as a direct loss or a crisis situation. The proposed ratios, which we have introduced for this purpose, generally cover the overall liquidity shock absorbing capacity, funding and off-balance sheet related risk, and the balance sheet maturity structure.

We have simulated four different scenarios. The first two scenarios (run on a bank and use of committed loans by counterparties) reflect typical risks resulting from banking activity. While a run on a bank can be the result of a bank's poor performance or the outcome of more severe problems, a use of committed loans can be triggered by a tightening of lending conditions. Both banks' bad performance and tightening of the lending conditions are usually related to adverse market developments, which increases the relevance of our choice for these scenarios. A run on the bank scenario is also proposed by Boss et al (2004) and Jurca et al (2006). Moreover, the Basel Committee on Banking Supervision (2008) also underlines the importance of testing the diversification of funding sources. Also Van den End (2009) stresses the importance of off-balance sheet contingencies, which are taken into consideration in our second scenario.

The third situation, a netting of the position with the parent undertaking is rather unlikely to happen; still it can help us to identify entities whose actual individual liquidity is positively or negatively affected by the group liquidity risk strategy. We did not find any similar scenario in the literature. However, the Basel Committee on Banking Supervision (2008) discusses the complexity of home-host liquidity regimes, which justifies the choice of such a stress scenario.

The last scenario, simulating a change in refinancing conditions with the Eurosystem, can be considered as rather theoretical in its nature. However, it shows the dependency of some banks on this funding source. The change in valuation haircuts applied in monetary policy operations seems to be a very relevant stress scenario, since according to the Banque centrale du Luxembourg (2009) the actual liquidity problems of banks can be largely explained by a decrease in asset prices.

To evaluate the liquidity risk for specific banks as well as for the banking sector as a whole, we first define liquidity ratios. Baseline values of these ratios serve as a benchmark for the evaluation. These ratios are stressed in different scenarios to calculate the stress values. Afterward, the stress values are compared to the baseline value. The magnitude of the relative changes between the baseline and the stressed value is used to identify the most severe scenario for the banking sector and the most vulnerable bank under all scenarios.

2.1 Data and sample

For our exercise, we have used the monthly statistical and prudential reporting data from January 2008 to December 2008. As the scenarios are based on ratios, we consider the data series long enough to contain the information necessary for our analysis. December 2008 data is also used as a baseline scenario.

The reference period data is principally used to identify the business model and the general behaviour of every bank in the sample. It is also used to calibrate bank-specific values of variables used in some scenarios.

The stress exercise is done on a sample of 32 banks established in Luxembourg. The total assets of the sample cover more than three quarters of the total assets of the Luxembourg banking sector. The sample contains banks of different sizes and activities, including banks with predominantly domestic retail activity, subsidiaries of large European banking groups with a diversified range of local and international activities and also subsidiaries or branches mostly involved in operations with the parent undertaking.

The heterogeneity of the sample, which reflects the landscape of the Luxembourg banking sector, has also influenced the choice of scenarios and the definitions of ratios described in sections 2.2 and 2.3.

2.2 Liquidity indicators

In this section we introduce four different liquidity ratios that are used as a proxy to measure the impact of the proposed stress scenarios. The structure of the ratios should cover the heterogeneity of liquidity risk channels of transmission as well as the heterogeneity of Luxembourg banks' business models.

2.2.1 Liquidity buffer ratio

The liquidity buffer ratio (LB) should give us an information about the general liquidity shock absorption capacity of a bank. As a very general rule, the higher the share of liquid assets (LA) in total assets (TA), the higher the capacity to absorb liquidity shocks, given that market liquidity and second round effects are the same for all the banks in the sample. Nevertheless, high value of this ratio may also be interpreted as inefficiency. Given the heterogeneity of activities of banks in the sample, there is no expected level for this indicator.[1]

For the purpose of this paper we define the liquidity buffer as follows:

$$LB = \frac{LA}{TA} \qquad (1)$$

$$LA = T + C_{CB} + 0.95(S_G) + 0.85(S_O + R_R - R_G) \qquad (2)$$

Where:

T Cash

C_{CB} Balances with central banks

S_G Debt securities issued by governments

S_O Debt securities, other than issued by governments

R_R Debt securities received as collateral in reverse repo trades

R_G Debt securities given as collateral in repo trades

TA Total assets

We assume deposits in central banks (C_{CB}) to be perfectly liquid, meaning that the central bank is expected to allow a bank to access these funds in case of need regardless of their maturity. A haircut of 5% is applied on the value of government bonds (S_G), which should reflect their relatively high liquidity. Debt securities other than government bonds and debt securities received in reverse repo trades have the same haircut of 15%. This assumption is a result of data availability, as we can neither distinguish between eligible and non-eligible for the Eurosystem monetary policy operations, nor discriminate between different types and maturities of eligible collateral.

[1] The benchmark value of this indicator depends on business activities of each bank and it is not the aim of this paper to specify it.

2.2.2 Deposit risk ratio

Unlike the liquidity buffer ratio (LB), which gives us rather general information, the deposit risk ratio (DR) is more focused on the bank's sensitivity to selected types of funding. In this ratio, we use the above defined concept of liquid assets (LA) as denominator and we have included deposits of households, enterprises and money market funds into the numerator to capture the banks' vulnerability related to these funding sources.[2] In other words, if the ratio is close to 0, the bank is not sensitive to these types of funding. If it is above -1 the bank is generally able to meet its obligations in terms of funding[3], meaning the liquid assets can cover these potentially volatile liabilities. A ratio lower than -1 indicates a bank's increased sensitivity related to deposit withdrawals:

$$DR = \frac{-D_H - D_E - D_{MF}}{LA} \qquad (3)$$

Where

D_H Deposits by households

D_E Deposits by enterprises

D_{MF} Deposits by money market funds

The composition of the numerator should reflect the heterogeneity of our sample in terms of balance sheet structure, as one quarter of the banks in the sample does not receive any deposits from households (D_H) and almost half of them does not receive any deposits from money market funds (D_{MF}), while 97% of the sample receives deposits from enterprises (D_E).

2.2.3 Off-balance sheet risk ratio

The funding liquidity risk is covered by the previous ratio, but there is no reference to the off-balance sheet activity or to the bank's capacity to fund potential asset purchases. The off-balance sheet risk ratio (OR) should give us an information on potential cash-flows from such activities

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[2] Note that in all formulas, items generating potential inflows (e.g. liquid assets, loan commitments received, etc) have a positive sign while items generating potential outflows (e.g. deposits, loan commitments or guarantees given, etc) are included with negative signs.

[3] This ratio does not include obligations resulting from off-balance sheet committed loans. This risk factor is included in the next ratio.

(e.g. loan commitments, guarantees, etc.). For this purpose we calculate the net financial off-balance sheet position[4] and we compare it to the liquid assets:

$$OR = \frac{G_R - G_G + C_R - C_G + O_R - O_G}{LA} \tag{4}$$

Where:

G_G Financial guarantees given

G_R Financial guarantees received

C_G Loan commitments given

C_R Loan commitments received

O_G Other commitments given

O_R Other commitments received

This ratio can be particularly interesting during periods of tightening of lending conditions, when some businesses might start to use the credit lines agreed before the actual change in the lending conditions takes place. In such a situation, loan commitments provided to these clients become a liquidity concern, as well.

In general, a positive value of this ratio implies a positive, or at least a neutral impact on the liquidity position, as potential cash inflows are higher than outflows. Negative values, down to -1, should be interpreted as negative impact on liquid assets, while the bank still holds the capacity to meet its obligations. Values below -1 indicate some vulnerability in this area.

2.2.4 Structural liquidity ratio

This last liquidity ratio is focused on the structure of the balance sheet, including mainly items with a maturity of less than one year. Unlike previous ratios, which deem to be more risk sensitive, the structural liquidity ratio (SL) can give us a longer-term insight into each bank's liquidity position. Generally, we compare the one year maturity mismatch resulting from different business lines to the total assets. In other words, we are interested in how important the one year liquidity gap (GA^{1Y}) is compared to the overall bank's activity measured by the balance sheet total (TA).

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[4] This calculation does not include derivatives.

There is no desirable value for this ratio; nevertheless this ratio should be interpreted together with the liquidity buffer ratio. As both ratios have the same denominator, i.e. total assets (TA), increased levels of the structural liquidity ratio (meaning a higher than one year liquidity gap) can be compensated by a higher liquidity buffer ratio. This would imply higher risk sensitivity on one hand, but also higher risk absorption capacity on the other hand.

For the purpose of this study we define the structural liquidity ratio as follows:

$$SL = \frac{GA^{1Y}}{TA} \quad (5)$$

$$GA^{1Y} = C_B^{1Y} - D_B^{1Y} + C_{NBC}^{1Y} - D_{NBC}^{1Y} + C_{CB} - D_{CB} - B_i^{1Y} \quad (6)$$

Where:

D_B^{1Y} Interbank deposits with a maturity of less than 1 year

C_B^{1Y} Interbank credits with a maturity of less than 1 year

D_{NBC}^{1Y} Deposits by non-bank clients with a maturity of less than 1 year

C_{NBC}^{1Y} Credits to non-bank clients with a maturity of less than 1 year

D_{CB} Advances from central banks

C_{CB} Cash and balances with central banks

B_i^{1Y} Issued debt securities with a maturity of less than 1 year

Maturities are not necessarily an indication of future cash flows, as many types of assets and liabilities do not behave according to agreed maturity. However, we consider this ratio to be a necessary complement to previous ratios.

2.3 Scenarios

In this chapter we define four scenarios to test the behaviour of the above defined liquidity ratios in different stress situations. The first two scenarios are rather standard; the third one reflects the host character of the Luxembourg banking sector and the last one addresses the growing refinancing activities of banks with the Eurosystem.

2.3.1 Run on the bank

The first scenario ($Sc1$) is a simple simulation of the withdrawal of a certain volume of deposits by households, enterprises and money market funds. By including households and enterprises in this scenario we focus on the primary funding sources affected by a run on a bank. Deposits by mutual funds may also move as a result of possible redemptions by their clients.

This scenario was tested in two versions. First ($Sc1a$), we apply the same parameters on all banks; second ($Sc1b$) we calculate the stress parameters for every individual bank based on its specific activity. The first approach ($Sc1a$) gives us more comparable results among the tested banks, while the second approach ($Sc1b$) takes into account idiosyncratic risks of individual banks related to their specific activity.

Sc1a:

In this scenario we simulate a 20% withdrawal of deposits by households, enterprises and money market funds. This haircut is applied on the total deposits of the respective counterparties not taking into account agreed maturities of different types of deposits. Based on recent figures from some banks we can conclude that during a stress situation sight deposits and term deposits of different maturities would behave in a similar way.

To calculate the stressed liquidity buffer ratio (LB_{Sc1a}), we simply deduct the volume of withdrawn funds, i.e. 20% of the above mentioned categories, from both the liquid assets (LA) and the total assets (TA):

$$LB_{Sc1a} = \frac{LA - 0.2(D_H + D_E + D_{MF})}{TA - 0.2(D_H + D_E + D_{MF})} \quad (7)$$

Similar calculations are made to stress the deposit risk ratio (DR_{Sc1a}):

$$DR_{Sc1a} = \frac{-D_H - D_E - D_{MF} - 0.2(D_H + D_E + D_{MF})}{LA - 0.2*(D_H + D_E + D_{MF})} \quad (8)$$

In the off-balance sheet risk ratio (OR_{Sc1a}), we do not change the numerator, as the off-balance sheet items are not directly affected by the deposits withdrawals:

$$OR_{Sc1a} = \frac{G_r - G_g + C_r - C_g + O_r - O_g}{LA - 0.2*(D_H + D_F + D_{MF})} \quad (9)$$

To calculate the stressed structural liquidity ratio (SL_{Sc4a}), some additional calculations are made to take into account the maturity structure of the respective categories of deposits. In this calculation, we assume that the deposits withdrawal will follow the respective actual maturity structure. As a result, we distribute the withdrawn amount to time buckets symmetrically to the distribution of the last observation of the reference period (see Annex A):

$$SL_{Sc1a} = \frac{GA^{1Y} - 0.2 * D_H * \frac{^{dec08}D_H^{1Y}}{^{dec08}D_H} - 0.2 * D_F * \frac{^{dec08}D_E^{1Y}}{^{dec08}D_E} - 0.2 * D_{MF} * \frac{^{dec08}D_{MF}^{1Y}}{^{dec08}D_{MF}}}{TA - 0.2 * (D_H + D_E + D_{MF})} \tag{10}$$

Sc1b:

In scenario $Sc1b$, we try to integrate more bank-specific features. Thus, unlike in $Sc1a$, the deposits withdrawal is not based on a factor of 0.2 applied uniformly to all deposit categories across all banks. To take into account the behaviour of different deposit categories in individual banks, we have calculated factors of withdrawal (w) for each deposit type in individual banks. It is defined as the share of the biggest monthly decrease of a deposit category during the reference period on the average amount of this deposit category during the reference period[5]:

$$w_H = \frac{\max(D_H^{jan-08} - D_H^{feb-08}, ..., D_H^{nov-08} - D_H^{decv-08})}{\overline{D_H}} \tag{11}$$

Where $\overline{D_H}$ is the average amount of household deposit during the reference period.

Coefficients for deposits by enterprises (w_E) and by mutual funds (w_{MF}) are calculated analogically.

Thus, the calculation of the stressed liquidity buffer ratio (LB_{Sc4b}) is the following:

$$LB_{Sc1b} = \frac{LA - (w_H D_H + w_F D_E + w_{MF} D_{MF})}{TA - (w_H D_H + w_F D_E + w_{MF} D_{MF})} \tag{12}$$

[5] It could be argued that the highest historical decrease is not an appropriate variable to simulate a stress situation, as the banks has already survived it. However this decrease is calculated based on monthly data (i.e. the withdrawal could have been distributed over 30 days) while the impact of our scenarios should be interpreted as immediate.

Similar calculations are made to stress the deposit risk ratio (DR_{Sc1b}) and the off-balance sheet risk ratio (OR_{Sc1b}):

$$DR_{Sc1b} = \frac{D_H + D_E + D_{MF} - (w_H D_H + w_E D_E + w_{MF} D_{MF})}{LA - (w_H D_H + w_E D_E + w_{MF} D_{MF})} \tag{13}$$

$$OR_{Sc1b} = \frac{G_r - G_g + C_r - C_g + O_r - O_g}{LA - (w_H D_H + w_E D_E + w_{MF} D_{MF})} \tag{14}$$

Analogically, to calculate SL_{Sc1b}, we distribute the withdrawn amount to time buckets symmetrically to the distribution of the last observation of the reference period:

$$SL_{Sc1b} = \frac{G^{1Y} - w_H D_H \frac{{}^{dec08}D_H^{1Y}}{{}^{dec08}D_H} - w_E D_E \frac{{}^{dec08}D_E^{1Y}}{{}^{dec08}D_E} - w_{MF} D_{MF} \frac{{}^{dec08}D_{MF}^{1Y}}{{}^{dec08}D_{MF}}}{TA - (w_H D_H + w_E D_E + w_{MF} D_{MF})} \tag{15}$$

2.3.2 Use of committed loans by counterparties

After analysing the aspect of funding liquidity risk, we focus on the banks' capacity to provide the loans they have committed to in a previous stage. Thus, we simply simulate the use of 50% loan commitments (C_G) by banks' clients. As a result, these committed loans become part of the balance sheet, generating a liquidity outflow:[6]

$$LB_{Sc2} = \frac{LA - C_G}{TA} \tag{16}$$

[6] The usage of committed loans can be simulated in several ways. Besides our approach, where we assume simple changes in the asset structure (liquid assets are sold to be replaced by the committed loan) we could also assume that there will be no real outflow. The committed loan would become a new asset, while the liabilities would grow by the same amount as this new loan was transferred to the counterparty's current account: $LB_{Sc2} = \frac{LA}{TA + C_G}$

Similar calculations are made to stress the deposit risk ratio (DR_{Sc2}):

$$DR_{Sc2} = \frac{LA - C_G}{D_H + D_E + D_{MF}} \tag{17}$$

As regards the stressed off-balance sheet risk ratio (OR_{Sc2}), loan commitments are simply removed from the numerator, as they become a balance sheet item. As for the denominator, they are deducted from the volume of liquid assets.

$$OR_{Sc2} = \frac{G_R - G_G + C_R + O_R - O_G}{LA - C_G} \tag{18}$$

In the case of the stressed structural liquidity ratio (SL_{Sc2}), the one year gap in the numerator is modified according to the use of the committed credit lines:

$$SL_{Sc2} = \frac{G^{1Y} + C_G \frac{{}^{dec08}C^{1Y}}{{}^{dec08}C}}{TA} \tag{19}$$

2.3.3 Netting of the position with the parent undertaking

This scenario should give us some general information about the role of the Luxembourg subsidiary / branch in the liquidity management of its banking group. By netting the related parties balance sheet (P_{RP}^{bs}) and off-balance sheet position (P_{RP}^{os})[7], we should get a proxy of the profile of the Luxembourg entity vis-à-vis its parent undertaking. The positions with related parties are defined as follows:

$$P_{RP}^{bs} = A_{RP} - L_{RP} \tag{20}$$

Where:

A_{RP} Assets: related parties

L_{RP} Liabilities: related parties

[7] In order to net the position with the parent undertaking we simplify the off-balance sheet position by including only the loan related items and not other items such as guarantees, derivatives, collateral, etc.

$$P_{RP}^{ob} = C_{RP}^{r} - C_{RP}^{g} \quad (21)$$

Where:

C_{RP}^{g} Loan commitments given: related parties

C_{RP}^{r} Loan commitments received: related parties

This generally means that banks with positive values of P_{RP}^{bs} and P_{RP}^{os} are net liquidity providers to their banking group. Netting these positions can result in either a long or a short net position, implying either a positive or a negative impact in terms of liquidity. Unlike previous generally negative or neutral scenarios, this scenario can bring both positive and negative results for different banks.

However, we should note, that there is a strong asymmetry in decision making between the head of a banking group and its Luxembourg entity. As a result, a potential netting of these positions is basically decided by the head of the banking group while the Luxembourg entities which are net liquidity providers cannot take an advantage from this position.

To stress the liquidity buffer ratio (LB_{Sc3}), we add the net positions to the liquid assets and we decrease the balance sheet total by the netted amount:

$$LB_{Sc3} = \frac{LA + P_{RP}^{bs} + P_{RP}^{os}}{TA - \min(A_{RP}, L_{RP}) - \min(C_{RP}^{r}, C_{RP}^{g})} \quad (22)$$

Concerning the deposit risk ratio (DR_{Sc3}), only the numerator (LA) is modified by the net positions as this scenario does not imply any changes to deposits.

$$DR_{Sc3} = \frac{LA + P_{RP}^{bs} + P_{RP}^{os}}{D_H + D_E + D_{MF}} \quad (23)$$

To apply this scenario to the off-balance sheet risk ratio (OR_{Sc3}), we add the net off-balance sheet position with the related parties (P_{RP}^{ob}) to the numerator and the total position with the related parties to the denominator:

$$OS_{Sc3} = \frac{G^r - G^g + C^r - C^g + O^r - O^g + P_{RP}^{ob}}{LA + P_{RP}^{bs} + P_{RP}^{ob}} \tag{24}$$

As for the stressed structural liquidity ratio (SL_{Sc3}), we use the maturity structure of interbank assets and liabilities to calculate the distribution of the scenario impact on the time buckets:

$$SL_{Sc3} = \frac{G^{1Y} - \frac{{}_{dec-08}^{1Y}C_B}{{}_{dec-08}C_B}(FA_{RP} + C_{RP} + G_{RP}^r + C_{RP}^r + O_{RP}^r) - \frac{{}_{dec-08}^{1Y}D_B}{{}_{dec-08}D_B}(B_{RP} + D_{RP} + G_{RP}^g + C_{RP}^g + O_{RP}^g)}{TA - \min(A_{RP}, L_{RP}) - \min(C_{RP}^r, C_{RP}^g)} \tag{25}$$

2.3.4 Change in refinancing conditions with the Eurosystem

In the last scenario, we try to identify banks that became dependent on the refinancing with the Eurosystem. In our definition of liquid assets (LA) in part 2.1.1, we use a haircut of 5% on government bonds and a haircut of 15% on all other debt securities, since the available data does not contain any information on the Eurosystem eligibility nor on the type of instruments. In this stress scenario we keep a haircut of 5% for government debt securities, but for all other debt securities we use a haircut of 30%[8] since many debt securities are illiquid or their price, in case of fire sale, would much depend on the actual market conditions which might not be favourable. The stressed liquid assets (LA_s) are defined as:

$$LA_s = T + C_{CB} + 0.95(S_G) + 0.7(S_O + S_R - S_G) \tag{26}$$

As result, all ratios are recalculated according to this modification:

$$LB_{Sc4} = \frac{LA_s}{TA} \tag{27}$$

$$DR_{Sc4} = \frac{-D_H - D_E - D_{MF}}{LA_s} \tag{28}$$

[8] For the explanation of valuation haircuts, see footnotes 13 and 14 on p. 26

$$OR_{Sc4} = \frac{G_r - G_g + C_r - C_g + O_r - O_g}{LA_s} \quad (29)$$

$$SL_{Sc4} = \frac{G^{1Y}}{TA} \quad (30)$$

3 Application on real data

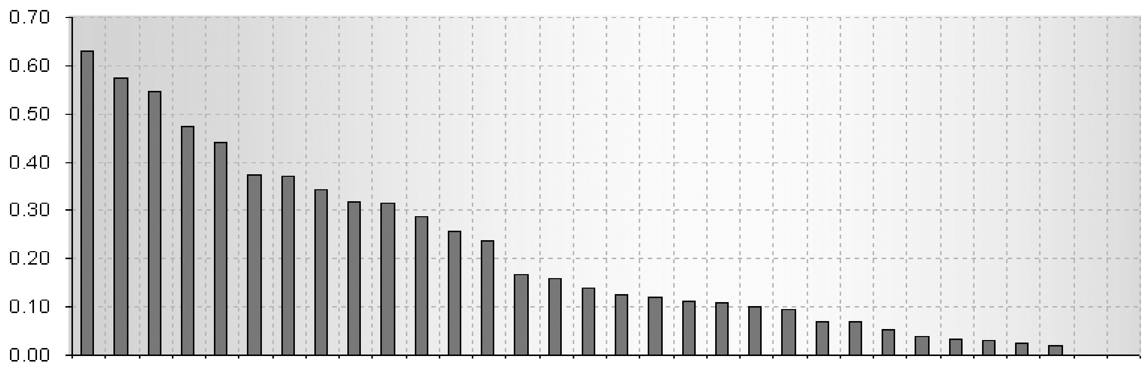
This part of the paper focuses on the real data exercise[9]. First, we calculate the values of the previously introduced ratios for December 2008, which serve as our baseline scenario. Then we calculate the stress values of liquidity ratios for all scenarios. Finally, we calculate the relative changes of the baseline and stress ratios to draw both individual and aggregated conclusions.

3.1 Baseline scenario

3.1.1 Liquidity buffer ratio

The liquidity buffer ratio is rather important in our exercise, since its numerator – liquid assets – is further used in the definition of deposit risk as well as the off-balance sheet risk ratio. Moreover, the liquidity buffer ratio is essential in the interpretation of the structural liquidity ratio. Therefore, we display in the following charts, the values of other liquidity ratios in combination with values of the liquidity buffer ratio. Chart 1 displays the distribution of the magnitude of the liquidity buffer ratio across the sample. :

Chart 1 Baseline scenario: Values of liquidity buffer ratio



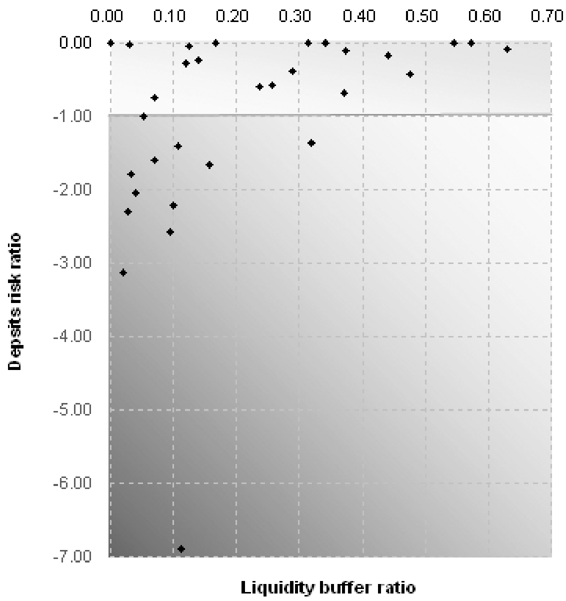
- Source: BCL, author's calculations
- Each bar represents a bank (axis x) while on axis y we observe the ratio's magnitude

[9] Explanatory notes on the sample and on the data used in this exercise can be found in the annex

3.1.2 Deposit risk ratio

The results for the deposit risk ratio are very heterogeneous, which reflects the differences in business models. For half of our sample, the volume of liquid assets could fully cover a potential withdrawal of all deposits by households, enterprises and money market funds. For 6 banks, the liquidity buffer was high enough to cover two thirds of the withdrawal. For the 10 remaining banks in our sample, the results were below -1.5, which means that these banks have 1.5 times more potentially volatile deposits than liquid assets (Chart 2).

Chart 2 Baseline scenario: Deposit risk ratio



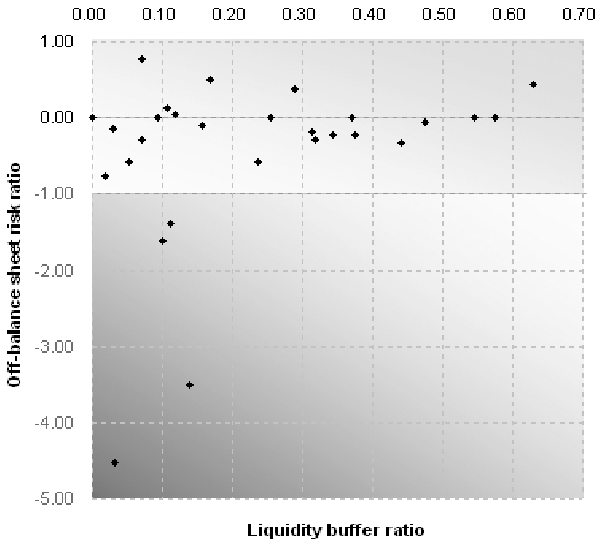
- Source: BCL, author's calculations
- Calculated for December 2008
- Chart does not include 1 outlier

Relatively lower values of the deposit risk ratio were in most cases the result of rather lower liquid assets than of increased levels of deposits.

3.1.3 Off-balance sheet risk ratio

According to the results, the off-balance sheet risk ratio seems to be complementary to the deposit risk ratio. The group of the banks with a relatively lower off-balance sheet risk ratio does not significantly overlap with the group of the banks with a relatively lower deposit risk ratio. There are only 6 banks with both values below -1 and only one bank with values of both ratios below -2. Still, some banks seem to be vulnerable as regards their off-balance sheet positions, as their potential demand for cash-flow largely exceeds their liquidity buffers (Chart 3).

Chart 3 Baseline scenario: Off-balance sheet risk ratio

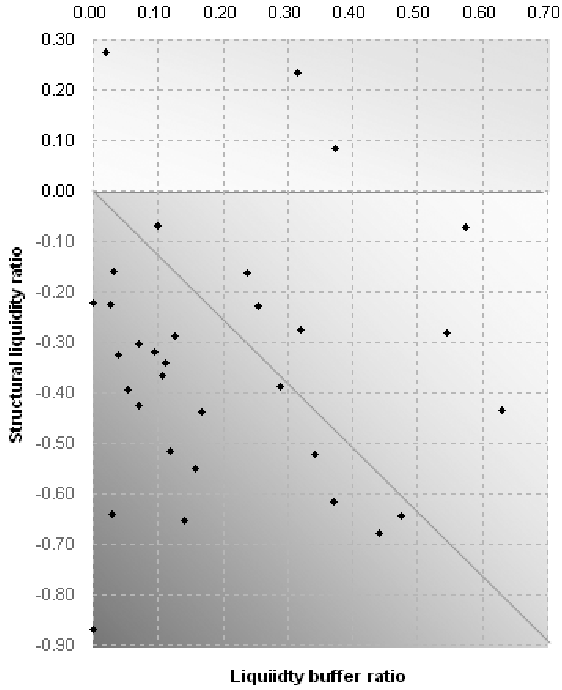


- Source: BCL, author's calculations
- Calculated for December 2008
- Chart does not include 2 outliers

<u>3.1.4 Structural liquidity ratio</u>

The maturity mismatch is a logical consequence of the role of banks, to act as financial intermediaries. Such activity implies short-term borrowing and long-term lending, which leads to generally short-term liabilities and long-term assets. Therefore, most of the banks (except 3) have a negative one year liquidity gap. Still, for some banks, the magnitude of this gap, measured by its share on total assets is inferior to the volume of liquid assets. In other words, this maturity mismatch could be covered by the liquid assets. These banks are located in the upper right triangle of the lower part of Chart 4. For banks in the lower left triangle of Chart 4, the volume of liquid assets is sufficient enough to close this gap.

Chart 4 Baseline scenario: Structural liquidity ratio



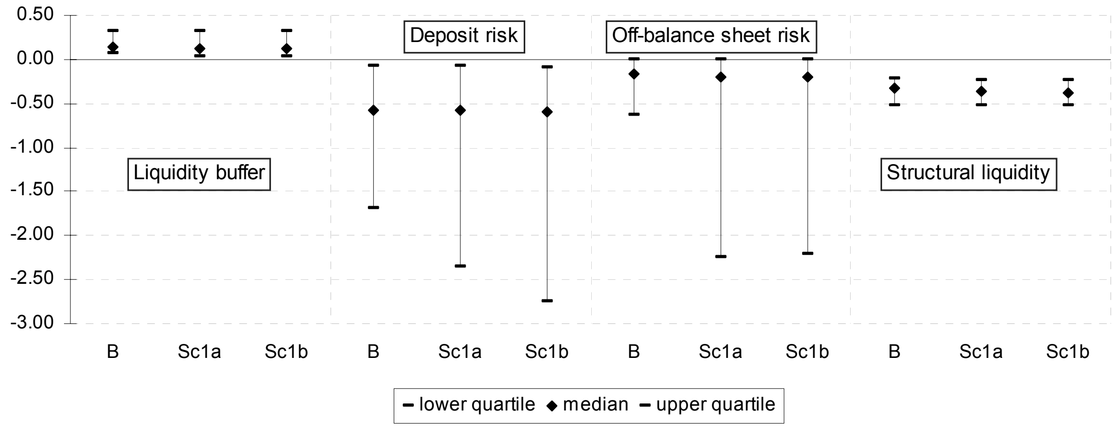
- Source: BCL, author's calculations
- Calculated for December 2008

3.2 Run on the bank (Sc1)

Half of the banks in the sample proved to be negatively exposed to the risk of a withdrawal of funds by households, enterprises or money market funds. These are generally those institutions were the liquidity buffer could not counterbalance the deposits withdrawals[10] (see section 3.1.2 and Chart 2).

[10] Note that the run on the bank scenario has a more severe impact on the off-balance sheet risk ratio than on the deposit risk ratio, which might seem to be a paradox (Chart 5). But it is a logical consequence of the ratios definition, where for the deposit risk ratio this scenario leads to a decrease of both numerator ($-D_H - D_E - D_{MF}$) and denominator (LA), while for the off-balance sheet ratio only the denominator is modified, as the numerator includes off-balance sheet items only ($G_r - G_g + C_r - C_g + O_r - O_g$).

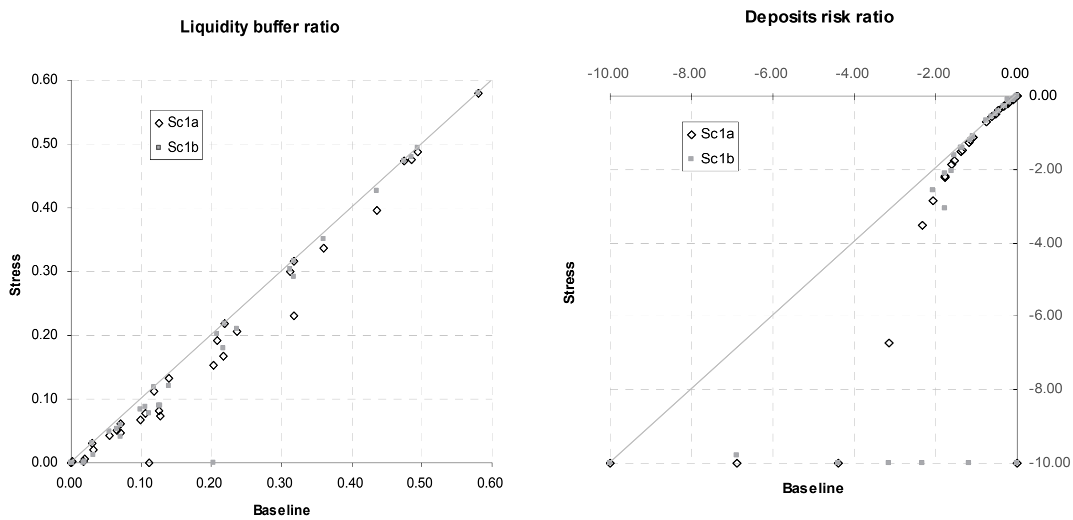
Chart 5 Impact of *Sc1a* and *Sc1b* on liquidity ratios



- Source: BCL, author's calculations

The scenario, which is taking into account idiosyncratic risks based on activities during the reference period ($Sc1b$), showed generally more severe results as regards the deposit risk ratio than a simple simulation of a 20% deposit withdrawal ($Sc1a$) (Chart 6).

Chart 6 Impact of *Sc1* on liquidity buffer ratio and deposit risk ratio



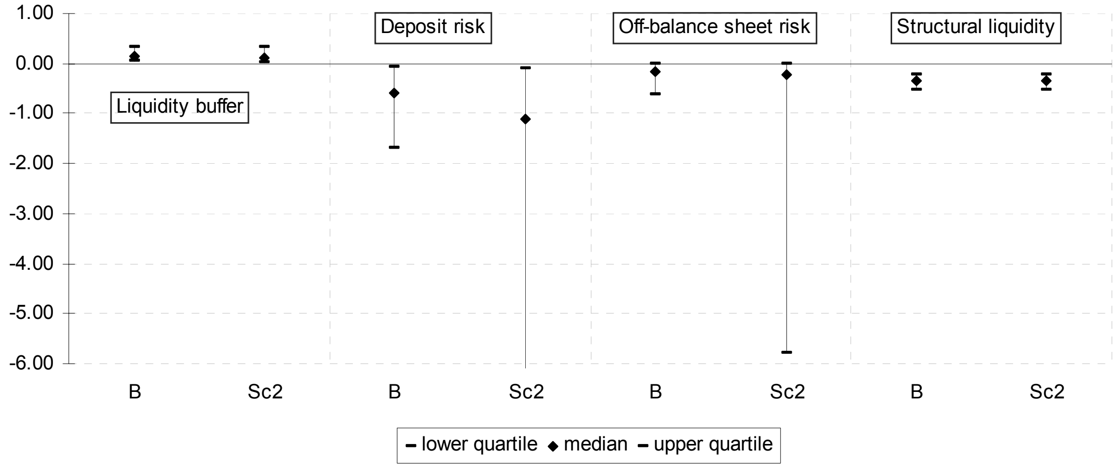
- Source: BCL, author's calculations

On the other hand a closer analysis of the impact of both scenarios on the liquidity buffer ratio showed that in $Sc1b$, most of the banks in our sample (22) witnessed a less severe decrease in their liquid assets than under $Sc1a$. (Chart 6).

3.3 Use of committed credit lines by counterparties (Sc2)

This simulation was applied only on 25 banks, as not all the institutions in our sample hold off-balance sheet loan commitments. From this subsample, 7 banks were not able to refund a potential use of 50% of the committed credit lines.[11]

Chart 7 Impact of *Sc2* on liquidity ratios

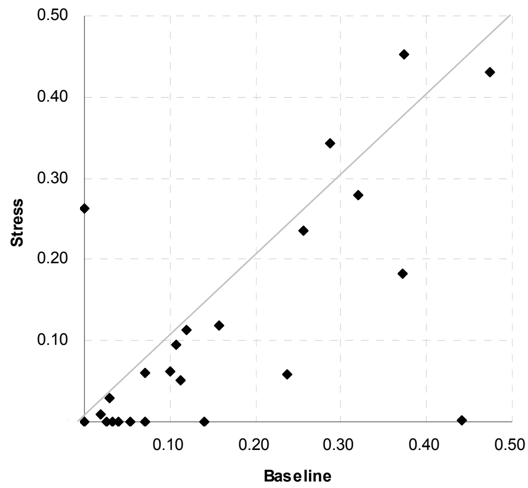


- Source: BCL, author's calculations
- Lower quartile of deposit risk ratio (not displayed on the chart) is -10.

On the other hand, 4 banks proved to be resistant to such a stress situation, as their liquid assets could cover not only the cash flow for the use of credit lines, but even after the simulation, they were resilient to potential outflows resulting from off-balance sheet positions.

[11] For banks where the liquid assets were completely consumed by the scenario and thus the calculation of the ratio is not possible according to the formula, a value of -10 was inserted.

Chart 8 Impact of *Sc2* on liquidity buffer ratio



- Source: BCL, author's calculations

When analysing more closely the liquidity buffer ratio, we can observe that all 7 banks which couldn't face the 50% use of the credit lines (located on horizontal axis) had baseline values below 0.15. Moreover, 6 of them are below 0.1 (Chart 8). As a result, we may conclude that the key risk factor in this exercise is the volume of liquid assets rather than the volume of loan commitments. Unlike the results of the deposit risk ratio which showed us that the volume of liquid assets is in most cases corresponding to the volume of deposits, loan commitments do not seem to be an integral part of liquidity risk management in this sense, at least for some of the banks in the sample.

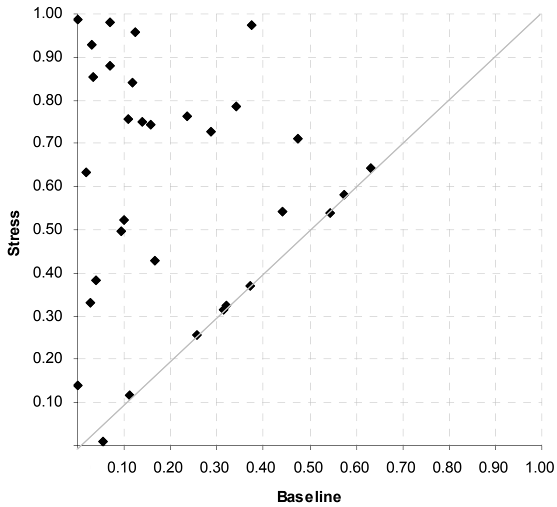
3.4 Netting of the position with the parent financial group (Sc3)

The first two scenarios (run on a bank and use of the committed credit lines) are of a more general nature and can be reasonably applied to the majority of banks in the EU. The importance of business done with the own parent undertaking, as well as the total long or short position in our sample is rather heterogeneous; still the model of net liquidity provider prevails[12].

As a result, this scenario resulted in both positive and negative impacts on banks' liquidity, depending on the character of the activity with the parent undertaking. Since most of the banks in our sample (and also in the Luxembourg banking sector) are net liquidity providers, the general impact of this scenario is rather positive.

[12] Situation where related parties liabilities are higher than related parties assets could be interpreted as an implicit liquidity dependence of the Luxembourg entity on funding from the parent undertaking

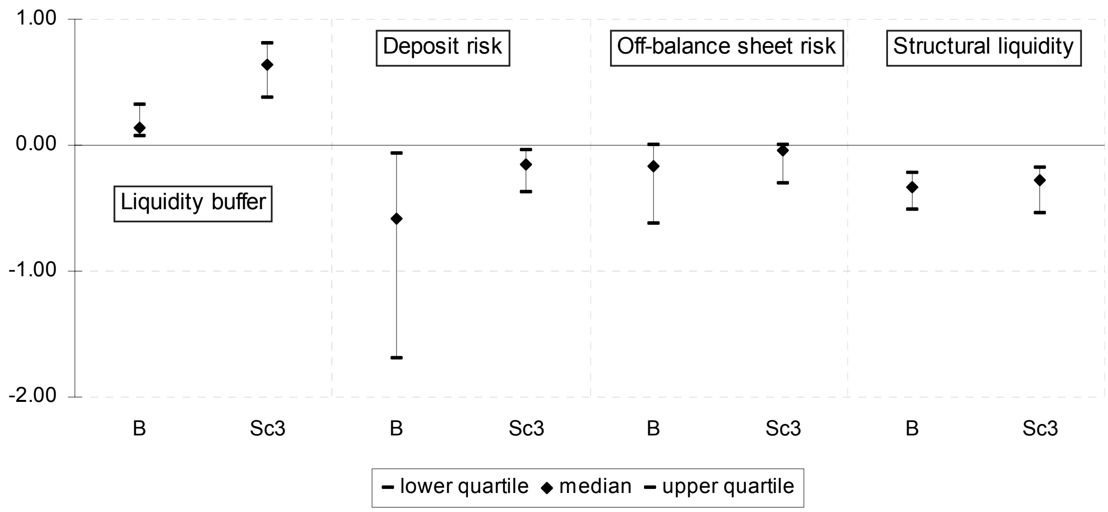
Chart 9 Impact of *Sc3* on liquidity buffer ratio



- Source: BCL, author's calculations

Results for this stress scenario are more heterogeneous than for the other scenarios. For some banks, characterized by baseline values close to 0, this scenario didn't change this value while for other banks, characterized by similar baseline values, the stressed values are much higher than the baseline values. There is only one bank in the sample which suffered a significant decrease in liquid assets in this scenario. (Chart 9)

Chart 10 Impact of *Sc3* on liquidity ratios



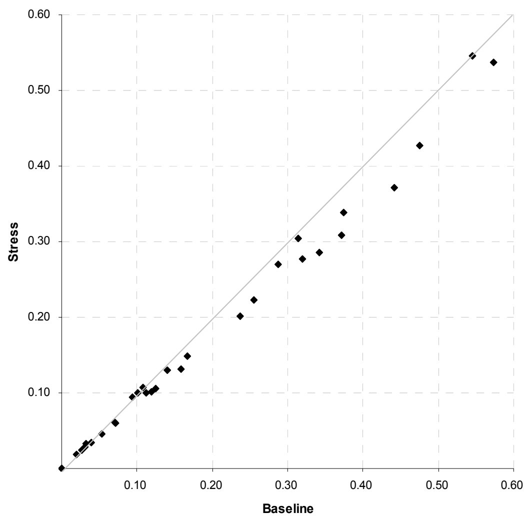
- Source: BCL, author's calculations

3.5 Change in conditions of the Eurosystem monetary policy operations (Sc4)

The last scenario is focused on one of the most discussed issues which have emerged during the financial crisis. Banks, which are recognised as eligible counterparties for the monetary policy operations can use eligible securities to access the liquidity facilities of the Eurosystem. According to the General documentation (ECB 2008), different haircuts are applied to the value of different types of eligible debt instruments. For other than government bonds, the valuation haircuts vary form 1 to 20%. Based on this, we use a haircut of 15% in our baseline scenario.[13] In this scenario we simulate a general increase in the valuation haircuts. Instead of using a 15% haircut for all debt securities other than government bond, we apply a haircut of 30%[14]. We keep the 5% valuation haircut for the government bonds.

In this stress scenario, the median liquidity buffer ratio fell from 0.13 to 0.11. For 5 banks the impact of this scenario was neutral or negligible. This implies that their liquidity buffers were composed mainly of government bonds and cash. (Chart 11).

Chart 11 Impact of *Sc4* on liquidity buffer ratio



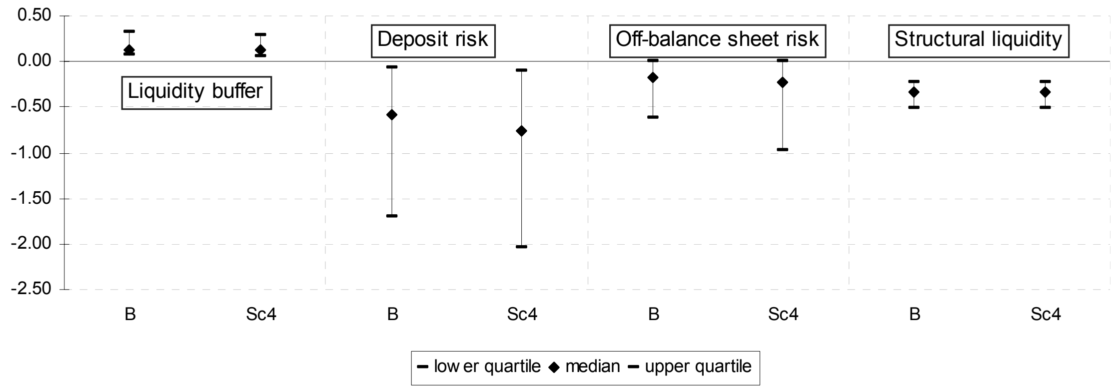
- Source: BCL, author's calculations

[13] A haircut of 15%, which is higher than the average haircut, is applied to take into account the fact that the available data does not distinguish between eligible and other securities.

[14] A haircut of 30% for the portfolio of debt securities other than government bonds could be argued to be too high. As this figure is based only on last available market data on trades with ABS from 2007 and recent fire sale estimation by specialised agencies, we welcome any feedback that would make this scenario more relevant.

Both the deposit risk ratio and the off-balance sheet risk ratio were hit by this decrease in the volume of liquid assets. The median value fell from -0.58 to -0.79 and from -0.17 to – 0.22 respectively (Chart 12).

Chart 12 Impact of *Sc4* on liquidity rations



- Source: BCL, author's calculations

3.6 Aggregation

In this part we try to answer two basic questions. First, which scenario was the most severe for the sample of banks representing the banking sector? Second, which banks seem to be the most sensitive in terms of liquidity risk? To answer these two questions, we first compare the stress value (R_s) and the baseline value (R_b) of all liquidity ratios, in all scenarios for all banks in the sample. The change of the baseline value into stress value is displayed as relative change (R_i) of the baseline value.

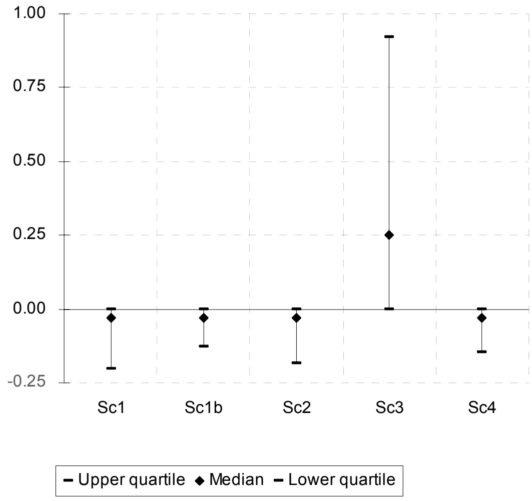
$$R_i = (R_s - R_b)/R_b \tag{31}$$

R_i is then a bank/ratio/scenario specific figure. All results for R_i are listed in annex B

3.6.1 Most severe scenario

To assess the most severe scenario, we calculate all R_i values. Then, in each scenario separately, we calculate the median value of R_i for all ratios, for all banks. The median of R_i was very similar for scenarios $Sc1a$, $Sc1b$, $Sc2$ and $Sc4$, i.e. at the level of -0.03. Moreover, the dispersions of results in these scenarios are not very different. As a result, it is not possible to make a clear conclusion about the most severe scenario on aggregated figures. However, it is a logical consequence of the heterogeneity of business models of banks in our sample, as there is no clear common liquidity risk factor. However, this should not lead to the conclusion that the exposure of the banks in the sample to liquidity risk is similar. The difference is not mainly caused by individual sensitivities to different scenarios, but also to the dispersion of the impact in $Sc3$ scenario. (Chart 13)

Chart 13 Median and quartiles of R_i in different scenarios

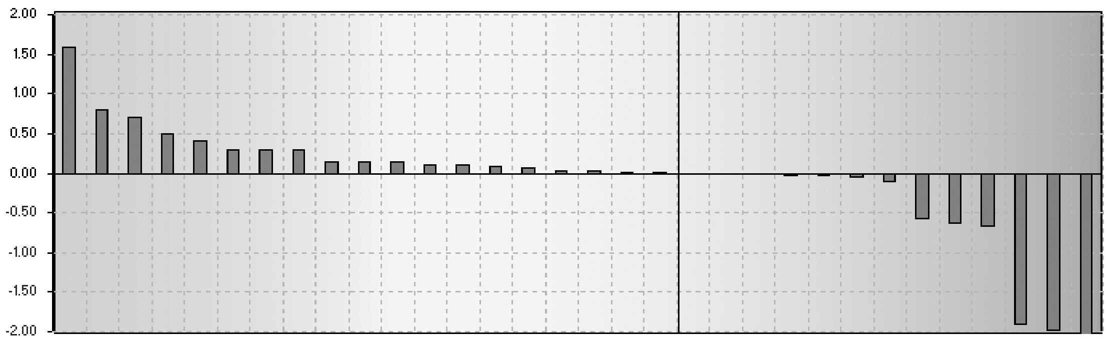


- Source: BCL, author's calculations

3.6.2 Most sensitive banks

To identify the most sensitive banks, we have calculated the average R_i value for each bank across all ratios in all scenarios (Chart 14).

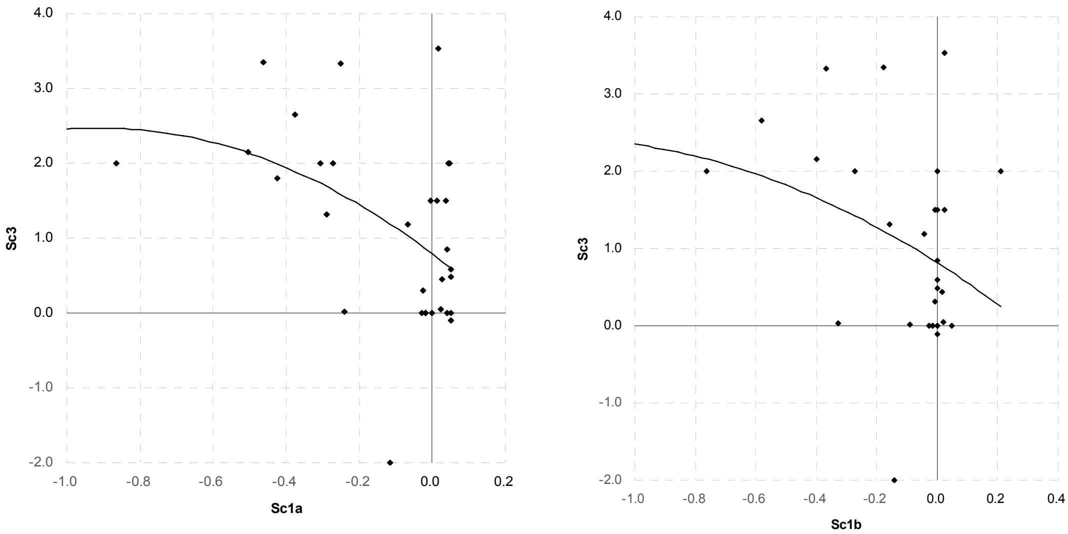
Chart 14 Average R_i values for individual banks across all ratios and all scenarios



- Source: BCL, author's calculations
- Each bar represents a bank (axis x) while on axis y we observe the ratio's magnitude

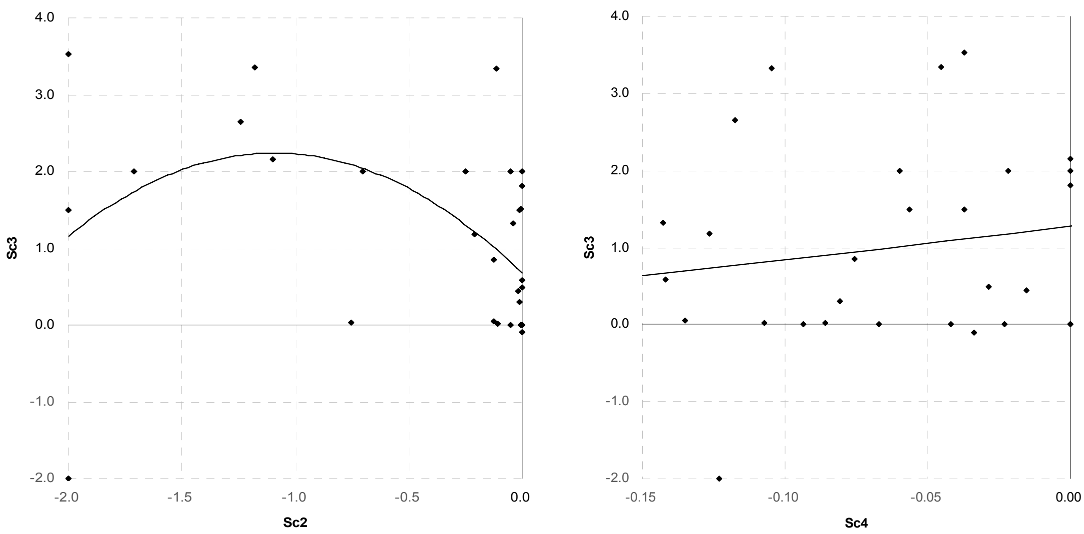
To have a better understanding of the impact on individual banks, we decompose the previous calculation of the average R_i values by scenario. As a result, we can identify banks being vulnerable as regards several scenarios as well as banks that show some vulnerabilities despite a positive overall average of R_i .

Chart 15 Average R_i values for individual banks of $Sc3$ vs. $Sc1a$ and $Sc3$ vs. $Sc1b$



- Source: BCL, author's calculations

Chart 16 Average R_i values for individual banks of $Sc3$ vs. $Sc2$ and $Sc3$ vs. $Sc4$



- Source: BCL, author's calculations

Since scenario $Sc3$ brought both positive and negative results with a rather high heterogeneity, we compare it to the results of the other scenarios (Chart 15 and Chart 16).

A short analysis of the run on the bank scenarios ($Sc1a$ and $Sc1b$) shows that only one bank of the sample is both sensitive to a withdrawal of deposits and weakened by an additional short position with the parent financial group (Chart 15). On the other hand, for most of the banks, the growing vulnerability as regards the deposits is accompanied by a positive impact of netting its position with related parties.

The impact of the combination of scenarios $Sc3$ and $Sc2$ - use of committed credit lines (Chart 16 - left) is different than of the combination of scenarios $Sc3$ and $Sc4$ - changes in valuation haircuts (Chart 16 - right). First, there does not seem to be any correlation between the impact of $Sc3$ and $Sc2$. However, the correlation between the impact of $Sc3$ and $Sc4$ is slightly positive.

It generally means that the banks, which are vulnerable as regards a potential change in valuation haircuts are usually not net liquidity providers for the parent financial group. In other words, in the case of these banks, the funding needs resulting from a change in the valuation haircuts applied on debt securities could not be automatically compensated by the positions with the parent undertaking. This is mostly the case for banks located along the horizontal axis (Chart 16 - right). Moreover, the scenario of a potential change in valuation haircuts would affect all banks in the Eurozone to a certain extent. Since the majority of the banks in our sample belong to a banking group based in Eurozone, the combination of scenarios $Sc3$ and $Sc4$ can be considered as the most severe.

4 Conclusions

In this paper we have simulated four different stress situations to calculate the impact on the liquidity situations of a sample of credit institutions in the Luxembourg banking sector. This impact is measured by relative changes of different liquidity ratios under different stress scenarios. The conclusions can be summarised as follows.

First, the Luxembourg banking sector is rather heterogeneous both in terms of baseline values of ratios reflecting individual banks' liquidity positions and in terms of vulnerability of different risk factors represented by selected stress scenarios. As a result, it was not possible to clearly identify the most severe scenario on an aggregated basis.

Second, for most of the banks in our sample, the financial relations with the parent undertaking is the most important liquidity variable. Indeed, this relation determines the degree to which a bank is exposed to different liquidity stress situations. In many cases, the negative impact of deposits withdrawals, off-balance sheet funding needs or stricter liquidity haircuts on debt securities could be, to a large extent, compensated by related parties' positions. Therefore, access to liquidity provided to the parent financial group is a crucial survival factor in a situation of liquidity distress.

Third, while it was not possible to identify the most severe individual scenario, it is possible to do so by combining the proposed scenarios. For this purpose, we have compared the impact of a run on a bank scenario, the use of loan commitments scenario and changes in liquidity haircuts scenario with the impact of the scenario of netted positions with related parties. Moreover, if we believe that the position with the parent financial group determines the individual liquidity shock absorption capacity, then we should always interpret the results of other stress scenarios consequently. Our analysis shows that in these combinations of scenarios, the negative impact of higher liquidity haircuts on debt securities was in many cases combined with relatively lower net long positions with the parent undertaking. Such a result makes the scenario of increased liquidity haircuts relatively more severe than the other two stress scenarios. Moreover, this scenario would also symmetrically affect the liquidity of the parent banking group.

Finally, if we do not take into consideration the business done with the parent financial group and try to understand the factors of individual liquidity risk vulnerability, then liquid assets play the crucial role. There seems to be a negative correlation between the individual banks' vulnerability in different scenarios and the share of liquid assets to balance sheet total.

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