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Liquidity Gap Report for Stress Testing Structural Liquidity Risk

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Abstract

The need to focus on banks' funding structure and stress testing in an explicit way arose as a consequence of the crisis of past decades. Liquidity risks usually occur as a consequence of other kinds of risks, hence analysing scenarios in a prospective manner is essential for the assessment if the bank can fulfill its obligations as they come due and if its funding costs are appropriate. The structural liquidity risk and the degree of the liquidity mismatch can be measured based on the liquidity gap analysis, where expected cash-in- and outflows, divided in different time-buckets are depicted. The liquidity gap report (LGR) shows if a liquidity shortcoming appears in the future and how high is the amount a bank would have to pay, if any hedging were not possible. This paper shows how to build a comprehensive LGR which is the base for both, liquidity and wealth risk evaluation. To improve the accuracy of the forecast, the counterbalancing capacity will be incorporated into the LGR. This tool is a methodological basis for quantitative and qualitative risk assessment and stress testing.

Keywords: Liquidity Risk, Stress-testing, Banks, Basel III, Counterbalancing Capacity

JEL Codes: C18, C81, G21, G28, G17

Introduction

Liquidity risks appear especially in historical financial crises, as in Asia and Russia crisis, LTCM and in the last crisis years which started in 2007 and developed to a global liquidity crisis in 2008 reaching a new dimension after the bankruptcy of Lehman Brothers (Rudolph, 2010, p. 22-24). The Euro-crisis in 2011 again led to liquidity strains. Initially only banks with an insufficient diversified funding structure, a considerable extent on maturity transformation and primarily financing on the capital markets faced difficulties. In the next stage liquidity decreased on the market as a whole. These developments have led to more attention to liquidity risks by financial institutions themselves, by regulatory authorities and by researches. Today, liquidity risk is considered as a substantial risk.

Basel Committee on Banking Supervision (BCBS, 2013 & 2014) introduced two liquidity ratios: liquidity coverage ratio (LCR) which requires banks to hold sufficiently large amount of unencumbered highly liquid assets to withstand a 30 days liquidity stress scenario and net stable funding ratio (NSFR) which requests to maintain a balanced maturity structure and a sufficiently stable funding which should be available even by a distress for one year.

But, calculation of liquidity ratios is not sufficient for a comprehensive monitoring and measuring liquidity risk. There are two important shortcomings of using ratios: The base on accounting data, historical developments and describing of a single view (Matz, 2011, p. 151). Even when the LCR and NSFR present an improvement, they do not show the whole picture of the liquidity situation. They focus on two time-points only: 30 days and one year. But, funding needs can appear in other moments too. Only one worst case scenario at a certain stress level is calculated. The costs of funding are not involved either. Therefore, additional stress tests and stress scenario analyses should be investigated.

Drehmann and Nikolaou (2009) define funding liquidity risk (FLR) as driven by the possibility that over a specific time horizon the bank becomes unable to settle its obligations immediately. The danger is loss of money under distress and following insolvency. The risk of liquidity maturity transformation is the risk of loss following a change in the own refinancing curve (spread risk) resulting from the misbalance in liquidity maturity

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transformation within a given time horizon at a certain confidence level. Hence, liquidity risk cannot be covered by holding of capital as the other kinds of risks. This study is focused on the structural liquidity risk which includes the above-mentioned definitions. It concerns the middle to long time period. The bank's liquidity risks arise due to its transformation function and clients' or market participants' payments. The requirement to meet payments at any time means that banks should be able to pay clients' demand even before the contractual maturity expires. There is no possibility to delay payments without loss of trust and reputation. Therefore, the basis for analysing liquidity risks are cash flows (CF) over a certain time horizon.

A liquidity gap report (LGR) sets the relevant cash-in- and outflows in a selected time period in relation and is therefore a suitable forward-looking tool for this purpose. It delivers an overview about a liquidity situation of different time horizons. It is the base for various liquidity risk measurements including the cost of FLR (Schmitt, 2016). No bank can afford to hold so much cash to survive a prolonged distress. Therefore, the maintaining of a counterbalancing capacity (CBC) is essential for the ability to generate enough cash even under a stress situation (CEBS, 2009).

Bank size and capital buffers may also affect the relation between liquidity and cost of funds (Khan, Scheule, & Wu, 2017, p. 2). A mistake often made is the underestimating of liquidity reserve changes or not including it in the stress test. The expected CF and the CBC cannot simply be added because of the eventuality of a double counting for some CF. The question is how to deal with the buffer and the CBC and how to integrate it into liquidity risk analyses and LGR. The aim is to create an overview about the liquidity amount which is available after the planned liquidity buffer and the CBC actions are absorbed. Thereby resulting gaps are the real liquidity needs. This study answers these questions and bridges a substantial gap between liquidity risk theory and banking practice.

The aim of the present research is to provide a better understanding of the underlying components for stress testing structural liquidity risk and to depict an approach for building a comprehensive LGR including CBC which suits the purpose of the analysis and measurement structural liquidity risks and estimation of funding costs under distress compared to the business as usual. For this reason, the explanatory manner is more suitable than a normative approach.

Related Literature

This study draws on the literature that relates to Matz (2011) and Neu (2007) who view the liquidity risk as a consequential risk, because it increases following one or more spikes in other financial risks. The definition of FLR is in line with Drehmann and Nikolau (2009) who define the funding liquidity as a flow concept and differentiate two components of FLR: 1. the future random CF, and 2. prices of obtaining funding from different sources. They use bidding data in the central bank auctions to asses this risks in two measures and define the net liquidity demand as the difference between outflows, contractual inflows and stock of central bank money. The present paper extends this determination by considering non-contractual and behavioural CF and the CBC.

Neu (2007) posts two basic principles for understanding liquidity costs: (i) they are depending on scenario, market conditions, bank balance sheet and the positioning of the bank in the market, and (ii) liquidity reserve reduces liquidity risks, but increases liquidity costs.

Based on the models of Fiedler (2007) and Pohl (2010) the approach for construction of a LGR will be depicted in line with CEBS (2009) requirements. Pohl (2010) describes a model for the calculation of present value of funding costs using a LGR. He does not include CBC into LGR. The present study closes this gap and shows how to combine the CF overview with a CBC (CEBS, 2010, p. 43). According to Fiedler (2007), the structural liquidity risk – the most probable future liquidity situation with counterbalancing capabilities – can be measured with a LGR analysis. He measures the value liquidity at risk as a possible change in the discounted value of the changed CF and shows the management of limiting risk by using expected CF.

Cooke, Koch, and Murphy (2015) denote the risk of being unable to fund assets-increases or meeting obligations immediately as a liquidity mismatch (LM) and measure it as difference in the liquidity weighted assets and liabilities to total assets. They show that LM helps predict distress one year ahead. Bai, Krishnamurthy, and Weymuller (2017) construct a liquidity mismatch index to investigate the mismatch between the market liquidity of assets and funding liquidity of liabilities. It preforms better than Basel III ratios. LMI-stress-test offers an early warning of banking-sector fragility.

Andreas, Hess, and Wanzenried (2014) found that banks with lower NSFR benefit from lower funding costs as a result of using less costly short-term funding. Khan et al. (2017) show the benefit of lower cost of debt funding and better financial performance due to increases in Basel III liquidity measures in relation with higher capital buffers. Mascia, Keasey, and Vallascas (2016) investigate the effects of capital regulation on the substitution between asset classes and the costs of financial intermediation. They show that IRB adopters, especially large banks, significantly increase costs of financial intermediation born by their customers.

Methodology and Data

This paper adds to the prior literature in a number of ways. First, it provides an explanatory framework for a link between an effective liquidity risk management and stress testing structural liquidity risk in the light of the current regulatory environment. It improves significantly on other methods used for funding and structural liquidity risk by presenting an approach for construction of a comprehensive LGR and including a CBC as a base for stress testing analyses which can take both components of FLR into account: the future random CF and the funding prices. The methods of description, analysis, synthesis, and deduction are used.

The analysis of a CF projection is based on the comparison of cash quantity available and cash required within a selected time period. The difference between these values is the liquidity gap or mismatch. In order to build an overview about the liquidity situation, assets and liabilities are grouped into time-buckets - time period sections, which are chosen depending on when a cash flow is expected.

Liquidity Gap Report

A comprehensive LGR consists of two parts. The first overview depicts an amount of cash needed in each time-bucket, also called the forward cash exposure (Matz, 2011, p. 170). The second overview shows the development of the CBC according to the same scenario for modelling CF (CEBS, 2009, pp. 20-21). These two parts add to the clarity, because it shows the amount of funds a bank really needs in the respective time-bucket. That means the cash required after a balancing capability of buffer was consumed. As the liquidity risk strongly depends on scenarios there is no overall valid and distinct LGR. The LGR can be constructed in the following six steps (Schmitt, 2015, pp. 62-68):

Determine a Scenario

Liquidity risks occur in the context of some underlying causes as a consequence of an initial problem which has an undesirable outcome expressed in loss of money. The quality of liquidity sources determines how long a bank will survive the distress. To get a picture of the probable future liquidity situation, possible future events must be modelled for stable and distressed market conditions starting with the bank's most apparent future liquidity situation, the business as usual.

The goal of developing scenarios is to be able to quickly identify if and when funding problems arise. Scenarios influence the CF modelling of each product differently. They also have impacts on liquidity reserves and liquidity sources which may be available in a special context, but can be restricted in another scenario. Therefore, assumptions about the cash effective stock development are to be set and scenarios have to be created for different stress levels.

Determine relevant financial products and their CF

Depending on the analysis perception and goal, relevant on- and off-balance-sheet products are selected. For example, from the funding point of view, the expected liquidity pathway should be mapped as exactly as possible. The new and prolonged businesses should be involved into the analysis. From the liquidation perspective, a fast possibility to sell assets is in the foreground. From the performance view, the costs and income of a product group or a portfolio are the point of interest. The forward payment structure can be determined only in some cases, otherwise it must be estimated.

The payment profiles of balance sheet positions enable a forecast of low volatility, but their expressiveness is limited. Hence, all products have to be considered as floating or option products, roll-over products, fixed-interest-rates products with longer term to maturity than a fixed-rate period, products with open commitments, credit lines and so on. The liquidity effect of securities portfolios, special funds and yield sensitive products have to be analysed in advance. The products are divided into investment, liquidity and trading holdings. According to this allocation, different cash flow pathways and hedging mechanisms are possible. Potential liquidity risks can also occur because of detrimental effects from uncertainty of CF forecast.

Categorise CF

Depending on the payment security and the time of payment, CF can be grouped in four categories as shown in Fig. 1.

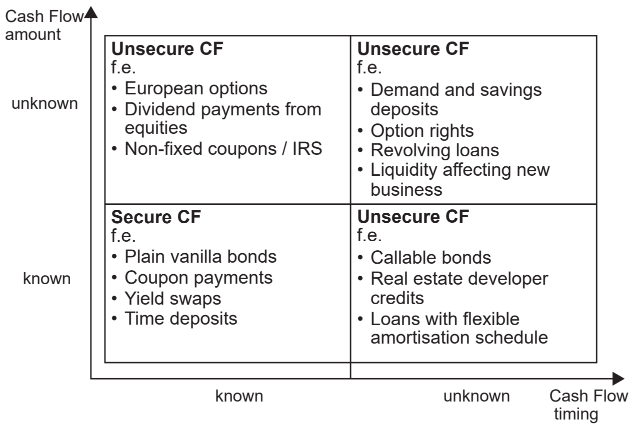

Fig. 1: Categories of CF

Source: Author's compilation according to Neu (2007, p. 24)

Depending on their type all CF are clustered, as shown in Table 1, in deterministic or contract dependent and stochastic: behavioural and hypothetic.

Secure or Deterministic CF

Secure CFs are apparent in contracted transactions and fixed agreement contracts. These CF are produced by periodic interest and capital payments, are known and can be stated by a predetermined process. The mapping is easy if the data quality and technical possibilities are good because the exchange rates, amounts, payment dates are clearly set. These types of CF are generated by bond and loans which are held in assets as well as in liabilities (Castagna & Fede, 2013, p. 112).

Insecure or Stochastic CF

Insecure CFs depend on ex ante not known different factors and are not determinable in advance. They result from specific designed contracts which bear behavioural components or are linked to market conditions (CEBS, 2010, p. 43). For example, the exercise time of options depends on future marked conditions and is time stochastic (Castagna & Fede, 2013, p. 113). Here are settled also hypothetical CFs. These are not only new or renewed prolonged businesses but also not yet existing businesses (Neu, 2007, p. 180). Under distressed conditions, modelling of alternative scenarios of possible bank activities even for otherwise as deterministic considered transactions is necessary.

Table 1: CF Allocation by Type

Types of Cash Flows		
	Stochastic	
Deterministic	Behavioral	Hypothetic
• Fixed agreement contracts • Cash position (mostly modeled in the overnight time bucket	• Options • Credit lines • Floating rate • Floating rate Instruments • Products with ex-ante unknown actions	• Non performing loans • New business • Prolongation of loans/business • Yet not existing business
→ Over a certain time horizon →		

Source: Author's compilation

Model a Forward Payment Structure of CF

Following the categorisation above, mapping of deterministic CF is straight forward, according to the contractual arrangements. To obtain a comprehensive view to the liquidity situation, stochastic CF must be estimated. It is not an easy task because some CFs are not yet existing, others depend on behaviour, hence there are several uncertainties which makes the modelling difficult (Fiedler, 2007, p. 177). There is no clear mathematical approach for the CF estimation and therefore, assumptions must be taken.

Best practices use a pragmatic estimation based on historical data or experts' experience (for more about the CF forecast, see Matz, 2011, Chapter 6-8). Fiedler (2000) presents a theoretical model where he takes into account that cash inflows and outflows in the respective time-bucket underlie different conditions. There are two models used: stochastic and behavioural. In the stochastic model, Monte Carlo Simulation is used to create CF scenarios for one future point of time. From the interest rate model correlations of the short-term payments are extracted, then regression model is constructed and subsequently the forecast for the behaviour of demand deposits using Cox, Ingersoll and Ross model is made. The behavioural models use historical payment structures and create forward projections by extrapolation. Here, the empirical behaviour structure is considered, as trend, cyclical patterns, frequency of specific situations and so on. The price for the accuracy is a higher modelling effort than in traditional methods.

Specify Time-Buckets

To get a forward-looking CF projection the so-called maturity ladder must be determined (EBA/ITS/2013, 07/2014, p. 22). Similarly to interest rate risk gap reports, the liquidity gap report groups the assets and liabilities into time period segments, the time-buckets, where the base is the point of time when the CF is expected, not when the products are expected to reprice (Matz, 2011, p. 156).

There is no general systematisation for assessing the time-buckets, the respective segments can be as long as needed: overnight, one day, one week, month or year or a combination of them. They depend on the business, on the nature of the positions' risk content and on the bank's risk appetite. Hence, the maturity pattern must be identified on a bank-specific base. (For example, a bank with a large amount of money-market papers is interested on a detailed short-term CF projection, but a mortgage bank which issues long-term loans and refinance them short- to middle term will be more interested on long-term view of CF developments.)

Generally, the forecast accuracy is higher in the short-term segments and decreases the further the projection period stretches into future. In Table 2, an exemplarily segmentation is shown.

Table 2: An Example for a Possible Structure of a Maturity Ladder/ Time-Bucket

Time Period	Frequency
1 Week	Daily
1 Month	Weekly
1 Year	Monthly
1-5 Years	Quarterly
> 5 Years	Yearly

Source: Author's compilation

Before reaching a decision about the time period segmentation it should be cleared if the length of the respective time-bucket will be oriented on calendar days or on another clustering type, for example, equal number of days per bucket. The calendar option enables to create time consistent buckets, so it will be preferred here. It can be divided as follows: time-bucket 1: start: 1. July 2016, end: 1. July 2016, frequency 1 day – the daily time-buckets follow until the time-bucket 9: start: 9. July 2016, end: 15. July 2016, weekly frequency and so on.

The time-buckets need not to be of the same length. If their length is large, aggregations of CF within a time-bucket are possible. Some compensations can occur which are not visible in the total, but there can be a dangerous liquidity shortage in between. This method risk can be avoided by drowning up of separate reports which should show

- the time-point of the lowest and the largest payment exceeding a given threshold
- all liquidity gaps exceeding a given threshold on daily basis in the respective time-bucket
- x lowest and y largest liquidity gaps exceeding a special threshold on a daily basis through all time-buckets.

Build a Liquidity Gap Overview

In the steps described above, the absolute amounts of expected CF for a given scenario in the respective time-bucket were modeled as cash-ins (ECF^+) and cash-outs (ECF^-). The expected CF is composed of such payments in each category (see table i) and can be written as (Fiedler, 2007, p. 182):

$$ECF^+ = ECF_D^+ + ECF_B^+ + ECF_H^+ \quad (1)$$

$$ECF^- = ECF_D^- + ECF_B^- + ECF_H^- \quad (2)$$

where ECF^+ is the sum of all cash-ins of the respective category, analogous ECF^- is the sum of cash-outs.

After being netted within the time-bucket the marginal liquidity gapNCF^t originates:

$$NCF_t = ECF_t^+ - ECF_t^- \; for\; t = 1, \dots, T \text{ (t is the number of the time} - \text{bucket). } (3)$$

This quantity shows the amount of cash-in the respective time-bucket t and represents a time-point view. It is not precise enough, if the risk manager is interested on the total exposure over a given time horizon. Such a view is obtained by accumulation of NCF_t *for* t=1,…,T because there is a possibility, that some previous liquidity gaps will compensate one another:

$$NCF_{kum,1} = NCF_0 + ECF_1^+ - ECF_1^- \text{ where } NCF_0 = initial\ stock \quad (4)$$

$$NCF_{kum,t} = NCF_{kum,t-1} + ECF_t^+ - ECF_t^- \quad (5)$$

This statement shows the picture about the liquidity situation, the amount and the location of liquidity gaps, over the selected time. Fig. 2 illustrates the principle of the LGR process.

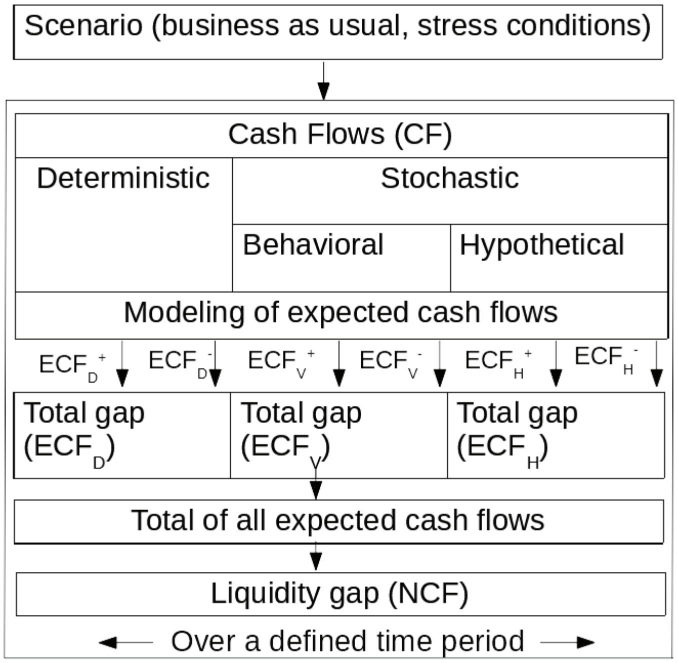

Fig. 2: Composition of Marginal Gap (NCF)

Source: Author's compilation

Often, after this step, the LGR is considered as ready for a further analysis. To obtain a comprehensive view to the liquidity situation the risk manager must not only know when and how large the possible liquidity shortcoming can arise, but also if there is enough liquidity buffer or further counterbalancing possibilities for liquidity provision to offset the negative gap (Matz, 2011, pp. 170-171; BCBS, 2008, Principle 5, 26, p. 11; CEBS, 2009, p. 22, 9). For that reason, additional steps are introduced.

The Role of CBC in Stress Testing Liquidity Risk

The CBC is composed of the bank's funding possibilities to cover the potential liquidity shortage over and above the business as usual scenario and in response to stress scenario for the entire time horizon of the bank businesses (CEBS, 2009, p. 10). Its hypothetical CFs are estimated in the same way as the other CF (Fiedler, 2007, p. 180; Matz, 2011, pp. 320-323). Under stressed conditions the bank is interested in reducing liquidity risk by taking low cost possibilities. For stress testing additional buffers are required (Bellini, 2017, p. 11). The guidelines on liquidity buffers depict the intention of CBC as: "counterbalancing capacity should, therefore, provide for greater requirements for funding under stress conditions, as well as a possible decrease in the value of any planned, or future funds, and hence it should always exceed normal levels assumed under business-as-usual in order to mitigate risks." (CEBS, 2009, Annex 1, p. 22) "…shall be viewed as the necessary and available funding under stress assumptions of a foreseeable nature." (CEBS, 2009, Annex 1, p. 22)

The CBC consists of two parts, as Table 3 shows, the liquidity reserve or buffer LRe and the secondary sources SLQ for providing liquidity in the form of reducing outflows or increasing inflows.

CBC=LRe+SLQ (6)

Table 3: CBC Components

Counterbalancing Capacity (CBC)	
Liquidity reserve (LRe) • Short term liquidity management • Cash •Highly liquid assets, unencumbered assets which can be quickly converted into cash without appreciable disagio	**Secondary Liquidity sources** (SLQ)) • Middle to long-term liquidity management • Means and measures: – To reduce or delay of outflows – To increase or expedite inflows – Collateralized funding

Source: Author's compilation, following Matz (2011, Exhibit, p. 170)

The LRe is defined for the short end of the time horizon focusing on stress situations (CEBS, 2009, pp. 22-23). It depends on three dimensions: strength and characteristics of the stress scenario, time horizon, and asset properties (CEBS, 2009, p. 3; BCBS, 2008, Principle 12). It consists of highly liquid assets to cover the sudden short time liquidity needs until they are compensated. Otherwise, the secondary liquidity sources must be taken. Its convertibility into cash depends on market conditions and relations to business associates. Hence, the time period, the "survival horizon", is the critical time span when the liquidity reserve can offset the liquidity shortcomings that means until the bank becomes illiquid (CEBS, 2010, p. 43). It is not only a function of the buffer size but also a function of cash flows during the critical time period (Matz, 2011, pp. 272-273):

$$SP_{t_0} = \max \{ n \mid \sum_{i=0}^{n-1} NCF_{kum,t_i} \leq CBC_{t_0} \}, t_0 = start\ point\ of\ time \quad (7)$$

The second part of the CBC serves as a mean for the long-term coverage of liquidity risk. No bank can afford to hold so much buffer that it could survive a prolonged distress. Hence, to determine the processes how to influence in- and outflows over a certain time horizon is essential for staying liquid even during critical situations. For example, issuance of covered bonds on the capital markets, a stable access to a repo market or availability of irrevocable commitments on the OTC markets can help increase cash inflows.

Hence, to the above six steps, for creation of a liquidity gap reports, the seventh step should be added:

Quantify CBC and Model Its CF

The liquidity buffer and all financial instruments and activities producing liquidity which belongs to the CBC should be modeled separately as shown in the steps above. The same scenario and stress level must be chosen for both part of the liquidity gap reports.

Inclusion of CBC into Liquidity Analysis

To answer the question if a bank will stay liquid in the future the CBC must be assessed in a way that the possible liquidity need does not exceed the hypothetical counterbalancing activities (Skoglund & Chen, 2012, p. 38). Hence, the following inequality must be fulfilled:

$$NCF_t + CBC_t > 0 \;=>\; CBC_t > -NCF_t\ for\ all\ t = 1, \ldots, T. \quad (8)$$

CBC has its own dynamics as it includes different financial instruments from different sources and their amounts depend on the market conditions. Hence, it makes sense to prepare a separate CBC report where the possible cash-ins and cash-outs in the respective time-bucket are depicted. The positions are divided into the time-buckets depending on their disposition point of time. As the other liquidity relevant positions, CBC depends on scenarios and its progression has to be considered for stress testing and for a protracted distress too (CEBS, 2009, pp. 21-22).

The same scenarios should be applied for $NCF_{kum,t}$ and for CBC simultaneously. The typical scenarios which affect both parts of LGR negatively are:

- Bank-specific Scenario: Rating downgrade with following cash drain with the following inability to sell own high-quality issues.
- Market-wide Scenario: Market liquidity squeeze, hoarding liquidity leads to difficulties of liquidity taking.

As can be seen, sometimes CBC can be affected hardly too, so additional liquidity providing activities are necessary. They should be applied when an accumulated gap has a lower amount than the cumulative cash flow result of the CBC.

Under the assumption that CBC consisting of LRe, secured (BF) and unsecured (UF) financing can offset the gap, the maximum on liquidity amount at the point of time t, a bank can generate is calculated as follows (Heidorn & Schmaltz, 2009, p. 116):

$$CBC_t = LRe_t + BF_t + UF_t \quad (9)$$

The eighth step for building a liquidity gap report should be added to finish the comprehensive view of the liquidity situation:

Compute CBC Liquidity Gap

Analogous to the marginal liquidity gap NCF_t the CBC_t gap is calculated (see Step 6). It is usually positive, because the selling of high quality assets provides liquidity. Negative amounts cannot be excluded, for example if repayments of a "pfandbrief", a covered high rated mortgage bond, after a certain time should be settled.

To obtain a realistic view to a liquidity situation, $NCF_{kum,t}$ and $CBC_{kum,t}$ have to be observed simultaneously to find out, if there is enough liquidity on the end of a respective point of time. The answer provides the totaling and the accumulation of the above quantities, as follows:

By regarding the elementary liquidity condition the following inequations hold true:

$$NCF_{kum,t} + CBC_{kum,t} > 0\ for\ all\ t = 1, \ldots, T \quad (10)$$

$$-\sum_{t=1}^{T} NCF_t < CBC_{kum,t} = \sum_{t=1}^{T} (LRe_t + BF_t + UF_t) \quad (11)$$

NCF_0 is the initial stock and is included in NCF_1 . (The primary liquidity and the daily loss-free sellable assets are assigned to the first time-bucket.) The bank has to hold enough liquidity in every point of time to fulfill payments required. A liquidity surplus at the point of time t+1 is not sufficient when in the point of time t a liquidity shortage occurs and there would be no possibilities to offset it by liquidity providing actions. (Fiedler, 2007, p. 184, 194, 195. BCBS, 2008, principle 6 demands a determination of limits for positions in each time-bucket, scenario and aggregation-level. The CBC has to be lower that the stated limit).

As shown above, the time-point view can be transformed into the time-horizon view which is the base for the further liquidity risk analyses. For the stress testing of the liquidity maturity transformation risk it is necessary to analyse the funding possibilities on the above basis and to integrate the CBC's funding possibilities into the risk quantification. The total cumulative liquidity gap is then calculated as:

$$CBC_{\mathrm{kum,t}} = CBC_{\mathrm{kum,t-1}} + CBC_t \; for \; t = 2, \dots, T \quad (13)$$

$$Gap_{\mathrm{kum,t}} = NCF_{\mathrm{kum,t}} + CBC_{\mathrm{kum,t}} \; for \; t = 1, \dots, T \quad (14)$$

The $\mathrm{Gap}_{\mathrm{kum,t}}$ calculated over all time-buckets depicts the expected liquidity situation for the given scenario and is a proper base for the further risk analysis and quantification.

Drawing up a Stress LGR

Two views can be assessed:

- View to wealth and earnings situation under stressed conditions without including CBC. The focus is on the CF of the business stock. It should be investigated how much money will be needed in the respective market scenario. Additionally, it should be examined how much cash can the bank rise in such a situation. This topic belongs to the management of liquidity buffer.
- The overall view to the impact upon yields under a given scenario, including the CBC.

For drawing up a stress LGR the base LGR for business as usual condition should be posed first (see steps 1-8). After, it is necessary to investigate, how to close the liquidity gaps, because this procedure can bear risks too. The funding cost component should also be considered.

Subsequently, the changes of risk factors as defined in the chosen stress scenario should be applied to the CF of the business stock and CBC. This leads to an alteration of the whole LGR. There are different LGR for every scenario and stress level. For the CBC additional possibilities of rising liquidity, matching to the given stress scenario, should be modeled. Similarly to the basis LGR, the gap-closing possibilities should be analysed. The benefit of the stress LGR is the comparison of upcoming cash outflows and possibly generable inflows, a liquidity cover potential, under distress.

Fig. 3 illustrates this two-phase process.

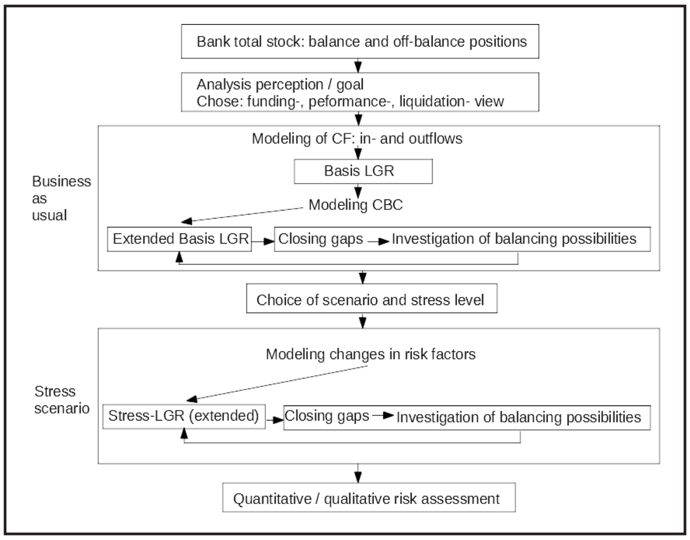

Fig. 3: Two-phase Process for Drawing up a Stress LGR

Source: Author's compilation

Several financial models use hedge actions for closing liquidity gaps. For the quantification of funding costs, costs of such hedges should be calculated. For this reason, an appropriate credit spread has to be adopted (for choice of credit spreads: Schlecker, 2009).

Results and Discussion

LGR of a Hypothetic Bank

In order to illustrate the way of functioning, construction and benefitting from LGR a simplified hypothetical example of a German mid-size bank with the balance sheet total 30 billion € is chosen (see Table 4).

Table 4: Hypothetical Example-Bank, Simplified

Assets	Mio€	Liabilities	Mio€
Cash	250	–	–
Stocks	300	Liabilities due to central bank	500
Bonds	6800	Deposits by banks	5000
Lending to banks	5250	Deposits by non-banks	9000

Lending to non-banks	17000	Debt securities (bank bonds)	14200
Particip-ations	600	Equity capital	1500
Total	30200	Total	30200

Source: Author's compilation on the basis of public available data, as annual and financial statements

The itemised statement of selected product groups, as in Table 5, shows a LGR for the business as usual scenario. The expected CF correspond to the funding view (see step 2). The CF structure is static, constructed on portfolio business at the observation time-point. The bank invests liquidity over the entire time-horizon. Interbank market funding is of minor importance but it shapes the short-term CF. The outflows in the long horizon are characterised by proprietary trading, lending and customer deposits. For fixed-rate positions a final maturity is considered. The same maturity structure and volume for replacements of expiring positions is adopted. The time-buckets are chosen on the calendar basis as follows:

- Four within one year: 1 month, 3 months (second - third month), 6 months (fourth – sixth month), 1 year (seventh – twelfth month)
- Four on a yearly base: 2 years – 5 years
- Two on a two-year base: 7 years (sixth-seventh year), 9 years (eighth – ninth year)
- In the last 10Y bucket include all positions with maturity 10 years and longer.

Table 5: LGR, Basis Case for Business as Usual

Stocks	150				50			50	0	50	0
Bonds	400	200	100	100	500	600	600	600	1200	1000	400
Lending to banks	1000	500	300	200	2000	800	400		0	0	0
Lending to non-banks	800	400	400	200	1700	1700	1000	1000	3400	4200	2000
Participations								100	0	0	500
Sum of Cash-In's	2350	1100	800	500	4250	3100	2000	1750	4600	5250	2900
Cash-Out											
Liabilities due to central bank	500				0	0					
Deposits by banks	1300	500	200	200	2000	500	200	100	0	0	0
Deposits by non-banks	300	100	100	100	500	500	500	800	2400	2500	1200
Debt securities (bank bonds)	400	200	200	100	1200	1500	1500	1500	3100	3100	1500
Equity capital									0	500	500
Sum of Cash-Out's	2500	800	500	400	3700	2500	2200	2400	5500	6100	3200
	0				0	0	0	0	0	0	0
Marginal (Netto Cash Flow) Gap	**-150**	**300**	**300**	**100**	**550**	**600**	**-200**	**-650**	**-900**	**-850**	**-300**
Accumulated Gap	**-150**	**150**	**450**	**550**	**1100**	**1700**	**1500**	**850**	**-50**	**-900**	**-1200**
CounterBalancingCapacity											
Cash	250										
Balances at central banks											
Central bank eligible securities	1200						-50	-150	-350	-400	-250
CBC-Pfandbrief (= very high rated mortgage	850						-50	-50	-150	-300	-300
Marginal CBC	2300	0	0	0	0	0	-100	-200	-500	-700	-550
Accumulated CBC	**2300**	**2300**	**2300**	**2300**	**2300**	**2300**	**2200**	**2000**	**1500**	**800**	**250**
Forward-looking liquidity overview	2150	2450	2750	2850	3400	4000	3700	2850	1450	-100	-950

Source: Author's compilation

The advantage of the above LGR is the timely balancing capacity planning for possible liquidity needs, funding capabilities and structure for a chosen time-point due comparing the $NCF_{kum,t}$ and CBC. By considering just the $NCF_{kum,t}$ liquidity demand of -150 mio € appears in the 1M bucket, following by -50 mio € in 7Y and -2.100 mio € in the further years. The CBC of this bank is prudently composed and equalises the gap so that the first liquidity demand which must be funded appears in 9Y bucket and further under normal circumstances.

The extent of a possible distress is made evident due to comparing business as usual and varying stress LGR. The investigation of the planned balancing capacity under distress should be used for the strategic decisions regarding the funding structure and costs.

Boundaries of LGR

For the modelling of expected CF assumptions are to be made for different scenarios. The risk manager faces a model risk, the results are based on appraised values. The following points should be considered too:

- For an appropriate LGR a large amount of data is necessary.
- With an onward time-horizon, the uncertainty about

the amount and the constitution of CF increases.

- The modelling effort for option-like products can be high.
- Terms for refinancing on the capital markets can be subject to strong variation so an exact planning or prognosis of funding costs is not possible.
- The involvement of new businesses into the LGR can be effortful; it incorporates uncertainty. Neglecting these positions leads to the distortion of liquidity risk: liquidity gaps would be larger.
- For a creation of an appropriate LGR and its consistently monitoring as well as adaptation of methods for the estimation of expected CF, adequate resources are necessary (personal, time, technical equipment etc.).

Conclusions

Liquidity risk is characterised by uncertainties in the prospective amount and timing of CF. Since liquidity risk is a consequential risk, CF projections depend on scenarios. Alongside the business as usual scenario, stress test should be modeled for different severity levels and for highly improbable events which could have disastrous consequences. According to Basel requirements, a qualitative assessment of liquidity risk is as important as a quantitative measurement.

No bank can hold sufficient liquid assets to ensure surviving a severe or a prolonged distress. The CBC plays here a substantial role. By adding the CBC into the LGR, the view of the overall liquidity situation can be sharpened. Since it is a prospective tool and CF are not known in advance, a quantitative approach to liquidity risk measurement is highly assumption driven. Generally, there is no clear mathematical way of deriving non-deterministic and uncertain CF. Hence, the largest weakness of LGR is its dependence on assumptions due to the modelling potential CF (Matz, 2011, p.172).

The present approach shows the possibility to integrate business stock and CBC without double counting of CF and for any scenario type. It is a methodological basis and a very efficient tool for further liquidity- and prosperity-risk measurements. As the example shows, even a small to mid-sized banks can easily implement the procedure for creating an integrated LGR.

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