Bank Liquidity Risk Management and Supervision: Which Lessons from Recent Market Turmoil?

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Abstract

The aim of the paper is to analyse the current liquidity risk management techniques and supervisory approaches, in order to identify how both could be improved in the light of the recent market turmoil caused by the sub-prime crisis and potential sources of instability directly connected with the 'originate-to-distribute' business model.

Current liquidity risk models demonstrated to undervalue extreme events affecting funding and market risk in global scenarios. At the same time, regulatory and supervisory regimes continue to be nationally based and substantially differentiated, pointing out significant differences which, in some circumstances, could generate regulatory arbitrages, as well as the effectiveness of supervisory actions could be reduced. The research, therefore, intends to highlight the most significant features to consider in order to implement an effective liquidity risk management and to achieve a more integrated supervisory framework for global financial markets. In this perspective, the effort of a regulatory authority to validate the adoption of internal models for liquidity risk is also investigated. Last, the paper analyses the most important lessons concerning liquidity management from recent episodes of stress.

1. Introduction[1]

The 2007 market turmoil caused by the sub-prime crisis highlighted how several key factors can strongly affect the banks' capability to keep their financial equilibrium under stress. As a consequence of the increase in interest rates in US and of the decrease of house prices, the default rate in sub-prime mortgages augmented significantly and, therefore, also structured securities based on such sector started to be downgraded. Rapidly, structured securities issued by bank-related special purpose vehicles experimented significant difficulties in raising funds in the money market and, consequently,

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sponsoring banks had to intervene in order to provide liquidity. However, liquidity on US interbank market rapidly dried up.

The crisis came as a surprise for financial markets, institutions and supervisory authorities because in the last years, in parallel with financial innovation and other key factors which are largely investigated in this research, financial industry was not able to develop sophisticated models in order to highlight the implications of some business lines (i.e., structured finance, securitisation, re-securitisation, etc.) on liquidity risk management. As a result, after August 2007 central banks had to carry on a significant effort in order to support both the functioning of money market and, in a few cases, individual institutions.

Financial markets are progressively reshaped by potential sources of instability directly connected with the originate-to-distribute business model. In order to allocate risk efficiently, this mechanism entails a number of threats, some of them intrinsic to its mechanism - products may be opaque, market liquidity may dry up, and some operators may not have strong incentives to screen and monitor their customers - others linked to the greater interdependence of the financial system. Even as systemic events may have become less probable due to diversification and risk dispersion, tail risk might be larger than how it is normally thought. At the same time, current liquidity risk models demonstrated to undervalue extreme events affecting funding and market risk in global scenarios. Furthermore, regulatory and supervisory regimes continue to be nationally based and substantially differentiated, pointing out significant differences which, in some circumstances, could generate regulatory arbitrages, as well as reducing the effectiveness of supervisory actions. In this framework, there is no confidence among regulators that capital requirements can be useful to prevent liquidity crises, despite in the last year it has been demonstrated that well capitalised banks are facilitated, *ceteris paribus*, in raising funds on interbank markets.

This paper, therefore, highlights the most significant features to take into consideration in order to implement an effective liquidity risk management and to achieve a more integrated supervisory framework for global financial markets. Last, the paper analyses the most important lessons concerning liquidity management from recent financial crisis.

The paper is structured as follows. Section 2 considers some definitions of liquidity and liquidity risk developed over time in the most significant multinational financial fora. In section 3 we analyse the most updated techniques used in order to measure the liquidity risk, while section 4 is devoted to the investigation of cash flow uncertainty and how it can be modelled. Section 5 extends the analysis to liquidity risk into VaR models and section 6 is dedicated to the implication of originate-to-distribute business models on liquidity risk management. Section 7 focuses on supervisory approaches on liquidity risk. Finally, section 8 offers some concluding remarks proposing some ideas for an effective liquidity risk management.

2. Liquidity and Liquidity Risk: Some Definitions from Multinational Financial Institutions

Liquidity in financial markets and intermediaries has several different meanings. First, liquidity represents the capability of a financial firm to maintain constantly an equilibrium between the financial inflow and outflow over time. As it is illustrated in the paper, banks can adopt different strategies and techniques in order to achieve such goal. Second, liquidity is a measure of the capability of a financial firm to turn an asset into cash quickly, without capital loss or interest penalty. In this meaning, the emphasis is focussed on the assed side of the balance sheet, since a potential source of liquidity can be achieved by selling, permanently or temporarily through repo operations, financial assets which are negotiated in markets having certain characteristics in terms of depth, breadth and size. Third, liquidity is somehow interpreted as the capability of a bank to raise funds on the wholesale financial markets - first of all on the unsecured interbank market - by increasing its liabilities. In a broader sense, liquidity can be considered as the aptitude of a financial firm to acquire funds when these funds are needed.

The nature of banking business implies that banks structurally invest in assets having a different degree of liquidity. Therefore, the liquidity of a financial firm involves several different managerial aspects. While a significant percentage of assets are illiquid and cannot be easily converted in cash, without incurring in losses, typical liabilities of banks and financial firms are more liquid and imply a considerable degree of discretion as far as the timing of depositors' withdrawal.

Thus, there are different elements to consider in order to analyse the liquidity of a financial firm. On one hand, traditional financial intermediation is based on different degree of discretionary power as far as the timing of use of funds. Consequently, the bank must maintain the confidence of depositors to have the faculty to withdraw their deposit on demand or at the scheduled moment. On the other hand, contemporary banking is based on more innovative financial services, which can also affect the capability of a bank to be liquid, as it has been demonstrated in 2007 financial crisis. The increase in the complexity of financial instruments, the securitisation, the growth of collateral usage and the trend to raise funds on wholesale capital markets are, among others, some of the reasons underlying the increase in the complexity of liquidity management in the financial firms.

In the light of above, liquidity risk can be considered as the risk that a financial firm, though solvent, either does not have enough financial resources to allow it to meet its obligations as they fall due, or can obtain such funds only at excessive cost. However, different institutions and authors, in diverse moments, highlighted several different features in defining liquidity risk. First of all, according to a supervisory approach, the Basel Committee on Banking Supervision since 1992 made the effort to define 'A Framework for Measuring and Managing Liquidity', stressing the fact that supervisory authorities have to differentiate the approaches for large international banks and domestic ones, as well as proposing different methodologies based alternatively on maturity ladder or scenario analysis in order to implement an effective liquidity management. Eight years later, the Basel Committee on Banking Supervision (2000) simply defined the liquidity as 'the ability to fund increases in assets and meet obligations as they come due'; in this framework, the Committee illustrated the evolutions in liquidity management and supervision, stressing, in fourteen key principles, the importance to design different managerial solutions for the day-to-day management of liquidity compared to the approaches to be adopted in emergency situations and the relevance to measure and monitor the net funding requirements. However, also this second paper did not identify dominant methodologies in order to assess and to manage liquidity risk. Nevertheless, the paper has the merit to clearly link, for the first time, liquidity risk to other typical risks of banking business, like credit risk, market risk and operational risk, as well as it dedicated a significant space to the importance of contingency plans against liquidity shocks.[2]

In 2006 The Joint Forum of the Basel Committee integrated the principles divulgated in 2000, proposing an 'integrate liquidity risk management across sectors' in financial groups, also considering the impact on liquidity of the off-balance sheet instruments and of on-balance sheet contracts with embedded optionality [3]. In this framework, following a classification previously adopted by the European Central Bank (2002), the Joint Forum differentiated the liquidity risk in *funding liquidity risk* (as 'the risk that the firm will not be able to efficiently meet both expected and unexpected current and future cash flow and collateral needs without affecting either daily operations or the financial condition of the firm') and *market liquidity risk* (which is 'the risk that a firm cannot easily offset or eliminate a position without significantly affecting the market price because of inadequate market depth or market disruption'). From this paper onwards, such distinction between funding liquidity risk and market liquidity risk became a common element in all the literature on liquidity risk management. However, still in 2006 the managerial practices adopted by banks for facing liquidity risk continued to be significantly differentiated and also supervisory authorities persisted to adopt dissimilar and heterogeneous models in order to assess the liquidity profiles of financial institutions.

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[2] See par. 4.

[3] These are contracts imply an implicit options for the counterparty, which can determine a liquidity outflow.

Thus, in order to review liquidity supervision practices in member countries, the Basel Committee on Banking Supervision at the end of 2006 established the Working Group on Liquidity (WGL). Such Working Group, which operated during the summer 2007 financial turmoil, functioned in a context of evidence that the models adopted by banks in order to predict liquidity crises demonstrated to be ineffective, the contingent liquidity plans were not always successful in avoiding liquidity crises, as well as did not consider extreme market events, which actually incurred; moreover, also the models used by supervisory authorities demonstrated to be excessively optimistic. The WGL terminated its study at the end of 2007 with a paper that the Basel Committee on Banking Supervision published in February 2008 as 'Liquidity Risk: Management and Supervisory Challenges'. The definition of liquidity risk suggested in this paper is in line with the previous ones identified by the Committee, but there is a clear emphasis on the equivalent relevance to manage liquidity by raising funds acting on the assets side and liability side, as liquidity risk is 'the risk that demands for repayment outstrip the capacity to raise new liabilities or liquefy assets'. Last, in June 2008 the Basel Committee published an updated draft for consultation of the 'Principles for Sound Liquidity Risk Management and Supervision' in which, stressing how the banking system did not adopted adequate models which efficiently considered liquidity risk posed by some businesses, the Committee updated the key principles for the management and supervision of liquidity risk. Among others, the paper emphasizes the importance of 'allocating liquidity costs, benefits and risks to all significant business activities', the necessity to identify and measure 'the full range of liquidity risk, including contingent liquidity risk' and the need for designing and using 'severe stress test scenarios'. These features are largely examined in this paper.

Beside the Basel Committee, other institutions in the last years investigated the liquidity risk. The European Central Bank (2002), despite did not provide an original definition of liquidity and liquidity risk, stressed the stochastic dimension of liquidity. In the ECB glossary, furthermore, there is a distinction between liquidity risk and insolvency, pointing out that the counterparty 'may be able to settle the required debt obligations at some unspecified time thereafter'. The Financial Stability Forum (2008), among the recommendations for enhancing the resilience of markets and financial institutions, dedicated a specific attention to liquidity risk, emphasizing the fact that supervisors and central banks have 'to promote more robust and internationally consistent liquidity approaches for cross-border banks'. As a response to such request, the EU Commission is consulting the public on possible improvements of the Capital Requirements Directive (Directive 2006/49/EC), in order to include specific requirements for liquidity risk in Europe.

At the same time, in last two years the European Union stated to closely investigate liquidity risk. On March 2007, the European Commission issued a Call for Advice asking the Committee of European Banking Supervisors (CEBS) to provide technical advice on liquidity risk management at credit institutions and investment firms. Thus, the CEBS recently issued and updated survey of the regulatory regimes across the EEA and published an in-depth analysis of the variables that may significantly affect liquidity risk management. According to the Committee of European Banking Supervisors (2008) liquidity risk 'can be seen as the potential threat to this cash generating capacity at fair costs, which is needed as a counterbalancing capacity at liquidity demands'. Such definition imply a dynamic view of liquidity risk, since the key element in order to face such risk is the perception of the cash generating capacity, which has to be sufficient for counterbalancing the unforeseen demand of liquidity.

3. Quantitative Framework for Measuring Funding Liquidity Risk

The analysis of liquidity requires bank management to identify, measure and monitor its positions on an ongoing basis as well as to examine how funding requirements are likely to evolve under various scenarios, including adverse conditions.

However, *'liquidity is difficult to define and even more difficult to measure'* (Persaud, 2007). Measuring liquidity risk can be a challenge, mainly because the underlying variables driving the exposures can be dynamic and unpredictable.

Until recently, managing and measuring liquidity risk was rarely seen as a high priority by most banks and financial institutions. Furthermore, no agreement existed in the international financial community and in the available literature on the proper measurement of liquidity [4]. There was not an integrated measurement tool able to cover all the dimensions of liquidity risk and commonly adopted by the majority of institutions.

As to liquidity risk metrics in use, it is necessary to distinguish between analytical approaches, such as VAR, that are focused on assessing potential effects on profitability (i.e. 'P&L effects') and liquidity risk models and measures, which aim at assessing cash flow projections of assets and liabilities, or the inability to conduct business as a result of a lack or a reduction of secured and unsecured funding capacity and/or liquid assets.

In the 'liquidity risk universe', banks generally apply a variety of measurement techniques - depending on which type of risk they want to assess (e.g. insolvency risk, funding liquidity risk, contingency liquidity risk, market liquidity risk, etc.) - with a different degree of sophistication and accuracy. In line with the stance taken by the Joint Forum's Working Group on Risk Assessment and Capital (2006), the main approaches to measure funding liquidity risk include a stock approach, a cash flow analysis and an unadjusted (or hybrid) maturity mismatch framework.

3.1. The Stock Approaches

The stock-based approaches look at liquidity as a stock. By comparing the balance-sheet items, these financial metrics aim at determine a bank's ability to reimburse its short-terms debts obligations as a measurement of the liquid assets' amount that can be promptly liquidated by the bank or used to obtain secured loans. The long-term funding ratio and the cash capital position are the most commonly used approaches based on liquidity stock.

a). The Long Term Funding Ratio
The best-known liquidity ratio - the long-term funding ratio (LTFR) - is based only on the cash flow profile arising from on- and off-balance sheet items of an institution. It indicates the share of assets with a maturity of *n* years or more, funded through liabilities of the same maturity[5].

$$LTFR = \frac{\sum_i Outflows_i (> n\_years)}{\sum_j Inflows_j (> n\_years)}$$

In a short-term horizon, the *LTFR* is frequently lower than 100 percent, because of maturity mismatches between assets and liabilities. Its evolution over time and the comparison with peer groups may draw attention to a potential maturity discrepancy between assets and liabilities (table 1).

Table 1:   An example of Long Term Funding Ratio

Balance Sheet Items	n = 5 Years	n = 10 Years
Assets (A)	1000	850
Funds Available (B)	850	700
Net Funding	1850	1550
Long Term Funding Ratio (B/A)	**85,00%**	**82,35%**

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[4] The available researches on the subject mainly tried to explain the limitations of the different techniques.
[5] Alongside this ratio, credit institutions often set limits also on roll-over risk, concentration risk, term transformation and so on, as these are important drivers for the liquidity risk that an institution is subject to.

b). The Cash Capital Position

A variant of the stock approach is represented by the Cash Capital Position (CCP) analysis. In general, in order to guarantee an appropriate balance sheet structure with respect to liquidity risk, illiquid assets should be funded by stable liabilities, or otherwise total marketable assets (TLA) [6] should be funded by total volatile liabilities (TVL)[7].

Consider the following balance-sheet's structure (table 2):

Table 2: Stock based approaches: the cash capital position

	Assets	Liabilities	
Liquid assets	Collateral value of unencumbered assets (=liquid asset excluding haircuts)	Short-term funding (CP, Euro CP, short-term bank facilities, etc.)	**Volatile liabilities**
	Cash	Non-core deposit	
	Reverse Repos	Repos	
	Total Liquid Assets (TLA)	**Total Volatile Liabilities (TVL)**	
Core and illiquid assets	Illiquid assets (e.g. fixed assets, intangibl., etc.)	Medium/long term funding Core deposits	**Core funding + Equity**
	Haircuts	Equity	
	Total on balance-sheet		
	Commitment to lend (CTL)	Steadily available lines of credit	

The difference between TLA and the sum of TVL and commitments to lend (CTL) is known as *cash capital position*. For example, in the previous balance-sheet *CCP* is calculated as[8]:

$$CCP = TLA – TVL - CLT$$

that is, highly liquid securities (i.e. cash, eligible assets, repoable bonds, etc.) should be able to replace for unsecured 'rating sensitive' funding [9]. CCP measures a bank's ability to fund its assets on a fully collateralized basis and ensures the bank to conduct business for the survival period [10].

If the result is negative, it means that illiquid assets are greater than long-term funding[11].

This approach is far more preferable framework to simply relying on other liquidity ratios, such as 'loan to deposits', because the latter ignores the quantity of loans that can quickly generate cash by either being pledged or sold [12]. Nevertheless, CCP has some drawbacks:

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[6] Total marketable assets (*TLA*) are primarily composed by cash, promptly reimbursable loans (i.e. mortgages that can be reimbursed without causing the borrower to meet financial distress) and unencumbered assets, that is widely marketable securities that are available to be used as collateral. Generally, they are calculated as the market value of net security positions after accounting for bond and equity financing transactions (i.e. reverse repo securities, borrowing securities, etc.). The collateral value is determined by subtracting haircuts, depending on security marketability from the current market value.

[7] Total volatile liabilities (TVL) include overnight and very short term wholesale funds, shares of customer demand deposits that could be claimed in the short term, such as save and sight deposits.

[8] As remarked by Resti and Sironi (2008), steadily available lines of credit are not included as third parties may be willing to face the legal costs of refusing to issue the loans to avoid creating new exposure to the bank.

[9] Rating sensitive funding is related to the fact that a part of banks' funding depends on the perceived riskiness, and therefore on the rating, of the bank itself.

[10] Moody's initially created the cash capital position to analyze the liquidity structure of a bank's balance-sheet as part of its external rating process. Its intention was to measure the bank's ability to fund its assets on a fully collateralized basis, assuming that the access to unsecured funding has been lost. For example, such scenario can occur after the downgrading of a bank's (short term) rating.

[11] All things being equal, this is a more challenging situation than a positive outcome, which points out that illiquid assets are more than fully funded by long-term funding.

[12] The loan to deposit ratio, or total loans divided by total deposits, indicates the degree to which a bank can support its core lending business through deposits; a sophistication of this ratio excludes from total deposits the more stable retained component, to demonstrate the degree to which credit business is actually supported by hot money. The above-mentioned ratio assumes that all sources of funding other than deposit are stable and all assets other than loans are completely liquid.

- it excludes the unfunded commitments, which the bank could be obliged to fund at anytime;
- it does not take into account of long-term liabilities that are maturing within a short-term horizon;
- it does not incorporate cash earnings generated by the bank's business;
- the discount applied to marketable securities could be too low and may increase at a time of greater illiquidity;
- furthermore, dividing balance-sheet items in 'liquid' and 'illiquid', there are no statements on when exactly positions can be liquidated or become due. Therefore, a binary approach is intrinsically unsatisfactory as it cannot appropriately consider the unlimited variety of liquidity degree.

In general, stock-based approaches are not forward looking and therefore not capable to cover all material aspects of the liquidity risk that an institution faces.

3.2. The Cash-Flows Based Approaches

A second group of liquidity models are those based on cash-flow. Often banking institutions control their liquidity principally by managing the structure of the respective maturities of their assets and liabilities, so as to generate adequate net cash flows.

In the cash-flow based approach, the 'essence' of liquidity risk is cash flow. Such metric principally aims at safeguarding the bank's ability to meet its payment obligations (that is funding liquidity risk) and calculating and limiting the liquidity maturity transformation risk, based on the measurement of liquidity-at-risk figures. Although this method is somehow recommended by the Basel Committee on Banking Supervision's (BCBS) Sound Practices of Liquidity Risk Management and seems to be accepted among the vast majority of supervisors as well, the details of the approaches used seem to be quite differentiated across the banking industry.

This risk measurement tool is based on a maturity ladder used to compare bank's future cash inflows - arising from eligible and marketable assets, illiquid products and established credit lines and outflows - including liabilities falling due and contingent liabilities, especially committed lines of credit that can be drawn down - both on a day-to-day basis as well as over a series of specified time periods (calendar date is considered as the starting point and it usually coincides with the following day), checking for their consistency (table 3).

Table 3: An example of the cash-flow based approaches: the (unadjusted) maturity ladder

Bands (upper limits)		ON	1 W	2 W	1 M	3 M	6 M	1 Y	>1 Y	TOT
Main expected Inflows	Loans	40	80	110	170	250	400	650	900	2600
	Securities			10	100	130	110	200	350	900
	Cash & Other	35								35
Main Expected outflows	Deposits	-10	-30	-50	-90	-200	-350	-590	-650	-1970
	Other Funding	-30	-30	-50	-50	-60	-50	-110	-80	-460
	Bond				-130	-160	-200	-300	-770	-1560
	CTL	-5	-25	-30	-20	-30	-110	-100	-100	-420
Net Funding Req. (NFR)		30	-5	-10	-20	-70	-200	-250	-350	-875
Cumulative Fund. Req. (CFR)		30	25	15	-5	-75	-275	-525	-875	

This grid allows to measure a *'cash flow mismatch'* or *'liquidity gap'* analysis; in its simplest structure such analysis is not supported by explicit assumptions on the future behaviour of assets, liabilities and off-balance-sheet items [13] and, consequently, a calculation of the cumulative net excess or shortfall over the time frame (T) for the liquidity assessment is performed.

$$CFR_T = \sum_{i \leq T} NFR_t$$

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[13] If a pure maturity mismatch approach is applied, only projected incoming cash flows are taken into consideration.

where *CFR* is the cumulative funding requirement and *NFR* represents the net funding requirement.

Typically, a bank may find substantial negative funding gaps over long-term horizons and will endeavour to fill these gaps by influencing the maturity of transactions, so as to offset the gap (graph 1). The excess or deficit of funds in each time bucket becomes a starting-point for a measure of a bank's future liquidity excess or shortfall [14].

Graph 1: An example of the path of the net cumulative outflows (NCO)

Net Cumulative Outflows (NCO)
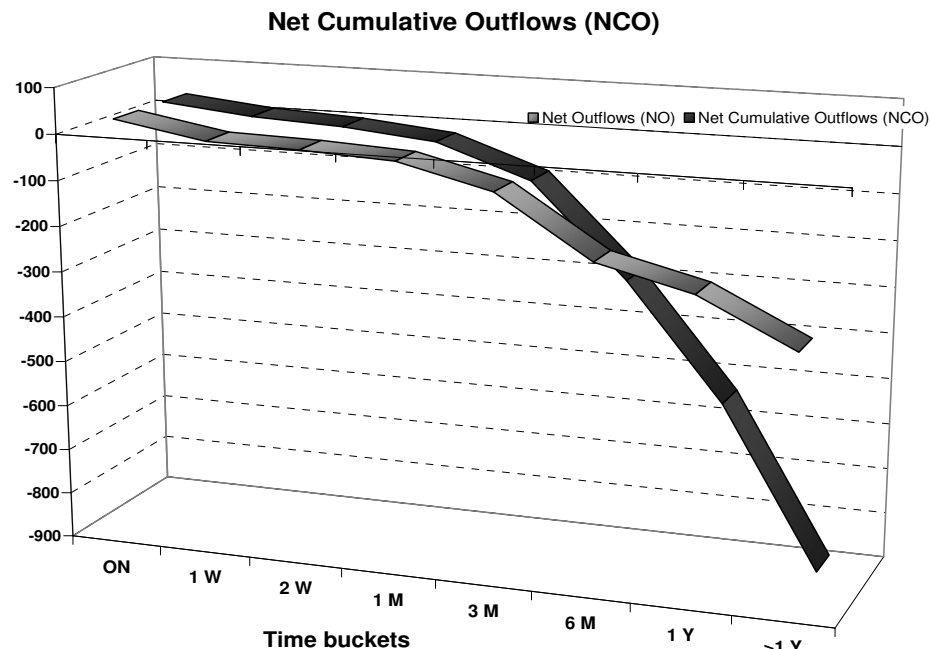
A maturity ladder can assume a multiplicity of structures and cash flows composition according to the different objectives, time horizons and business units involved (i.e. Treasury Unit, Risk Management Department, Economic and Financial Planning, etc.). For instance, the 'operational maturity ladder' supports the definition of the short-term funding strategy and the monitoring of a bank risk limit's system (table 4).

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[14] The granularity of time horizons must be carefully considered. While an extremely detailed cash flow breakdown can provide valuable information, it can also generate a certain amount of confusion in interpretation. This is particularly true if a bank is operating in a very dynamic environment, where cash flows arising in two or three weeks might change. The optimal level of granularity should be chosen in accordance with the previous experience.

Table 4:   Cash flows projections: same metrics, different time horizons.
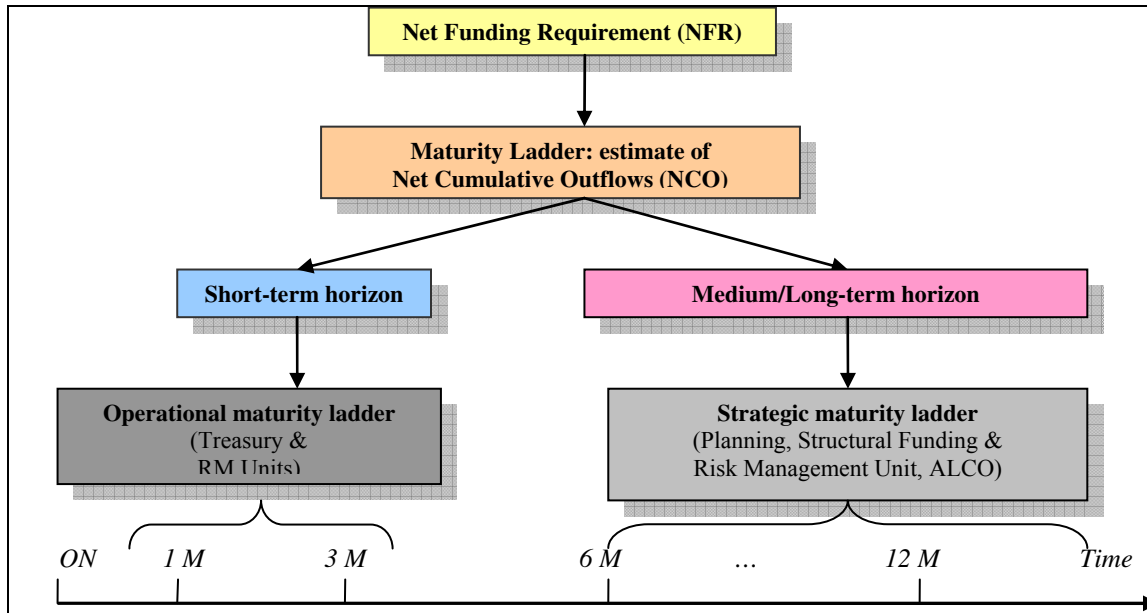
The main purpose of maturity ladder is to simulate the path of short-term treasury liquidity gaps, based on neutral assumptions on balance sheet items' future growth. Because of the shortest time horizon of the operational maturity ladder (e.g. up to 3 months), the balance sheet items included in such maturity ladder belong to the treasury book: short-term cash and derivative wholesale instruments interbank and institutional clients deposits, repurchase agreements, cross currency swaps, MTN, CD/CPs, etc. Other items, like high volatile trading assets, cash accounts and credit cards are not integrated in the analysis because they are considered stable or too tricky to predict [15]. Money and capital market positions are managed dynamically on contractual maturity basis.

3.3. The Hybrid Approaches

The hybrid approaches combine elements of the cash flow matching and of the liquid assets approaches. The idea underlying these models is that every credit institution is exposed to unexpected cash in- and outflows, which may occur in the future because of unusual deviations in the timing (*term liquidity risk*) or magnitude (*call liquidity risk*) [16], so requiring a considerably larger quantity of cash than the amount needed for bank projects. For this reason, the bank tries to match cash expected and unexpected outflows in each time bucket against a combination of contractual cash inflows, plus inflows that can be generated through the sale of assets, repurchase agreement or other secured borrowing. Unencumbered assets, that are used as collateral in financing transactions securing access to adequate funding sources (e.g. interbank lines of credit, discount facilities with central banks, etc.) and most liquid assets are typically counted in the shortest time buckets, while less liquid assets are counted in later time buckets (table 5).

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[15] The positions do not considered in the operational maturity ladder scheme are assumed to be passively managed or ex-post funded on an overnight basis.

[16] Cash flows with non deterministic timing are for example early redemption clauses or triggers. Examples for cash flows not deterministic in their magnitude but in their timing would be European options, dividends or, more generally, non hedged cash flows in a foreign currency. Cash flows that are stochastic in their timing and in the magnitude stem from American options or deposit withdrawals.

Table 5: An example of hybrid approach and the liquidation horizon

Band (upper limit)	Based on Maturity	Based on liquidation horizons
ON	0	550
1 W	0	100
2 W	10	100
1 M	100	50
3 M	130	0
6 M	110	0
1 Y	200	50
> 1Y	350	50
Total	900	900

Even though a strong (regulatory or economic) capital position is a prerequisite for high-investment grade rating and, consequently, improves funding costs and accessibility and contributes to the reduction of the likelihood of liquidity pressure, capital is not considered an appropriate *risk cushions* in stressful conditions or liquidity shortage. In such context, bank capital is usually replaced by a mix of risk management techniques in order to reduce the *net cumulative outflows (NCO)* and by a surplus of *unencumbered assets* to counterbalance *NCO*. The implied suggestion is that liquidity risk is adequately covered if the cash inflows, which could be generated from unencumbered eligible assets (UEA) within a time interval *T*, go beyond the net cumulative outflows within the same time horizon. In this framework, it is necessary to do some hypothesis on the capability to raise funds from eligible assets (graph 2).

**Graph 2:** An hypothesis of treatment of eligible assets
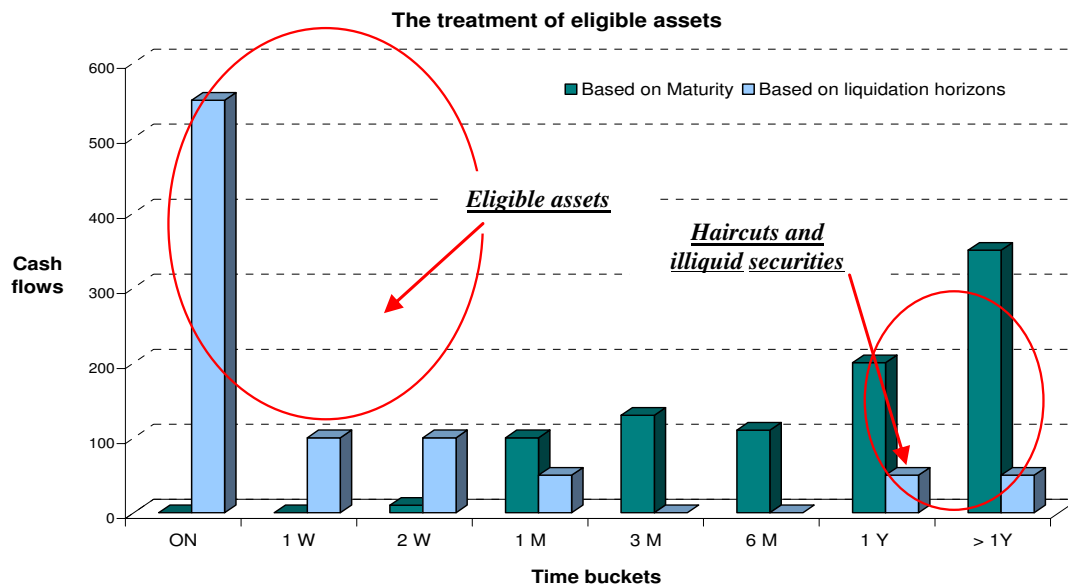
As shown in the table 6, the adjusted liquidity gap is now positive on all time buckets shorter than a year.

Table 6:   The mixed approach: an example of adjusted maturity ladder

Bands (upper limits)		ON	1 W	2 W	1 M	3 M	6 M	1 Y	>1 Y	TOT
Main expected Inflows	Loans	40	80	110	170	250	400	650	900	2600
	Securities	550	100	100	50			50	50	900
	Cash & Other	35								35
Main Expected outflows	Deposits	-10	-30	-50	-90	-200	-350	-590	-650	-1970
	Other Funding	-30	-30	-50	-50	-60	-50	-110	-80	-460
	Bond				-130	-160	-200	-300	-770	-1560
	CTL	-5	-25	-30	-20	-30	-110	-100	-100	-420
Net Funding Req. (NFR)		580	95	80	-70	-200	-310	-400	-650	-875
Cumulative Fund. Req. (CFR)		580	675	755	685	485	175	-225	-875	

4. The Role of Uncertainty and how it can be Modelled

Events in the second half of 2007 and early 2008 highlight the crucial importance of liquidity to the functioning of markets and the banking sector as well as links between funding and market liquidity risk, interrelationships of funding liquidity risk and credit risks, reputation effects on liquidity, and other links among liquidity and other typical banking features. Liquidity risk is not an 'isolated risk' like credit or market risks (although credit risk often arise as a liquidity shortage when the scheduled repayments fall due), but a 'consequential risk', with its own intrinsic characteristics, that can be triggered or exacerbated by other financial and operating risks within the banking business (graph 3)[17].

Graph 3: The link between liquidity and other typical risks
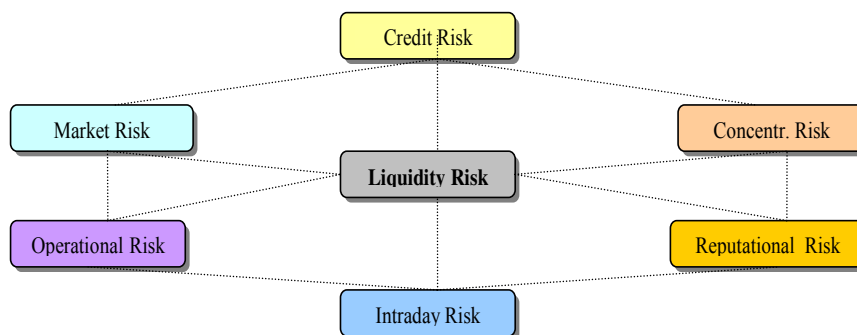
These interactions have gained in significance and involve that banks progressively more need to adapt their systems to control liquidity risks in a manner consistent with their business models. Furthermore, the relationships with other risks tend to create uncertainty with regard to liquidity risk measurement and to the management of a bank's liquidity gap profile[18].

Traditional liquidity measures, making use of time series, too often exclude off-balance sheet commitments (and the numerous risks connected to them), and fail to capture any dynamics of liquidity

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[17] Using a large data set on credit default swaps, Chen et al. (2005) studied how default risk interacts with interest-rate risk and liquidity risk to jointly determine the term structure of credit spreads. Through model construction and estimation, they found that credit-risk dynamics differ across different industry sectors and credit rating groups, but in all cases they show intricate interactions with the interest-rate dynamics and liquidity.

Brunnermeier and Pedersen (2008) found that market liquidity and funding liquidity conditions can be mutually reinforcing, leading to a loop, known as "liquidity spirals".

[18] For example, as to market risks, adverse market conditions tend to create uncertainty with regard to the value of assets in the liquidity management framework. Margin calls on derivatives transactions implied by negative market developments also have repercussions on liquidity risk. As far as intraday liquidity risk is concerned, severe disruptions in significant payment systems could also affect money markets conditions. In addition, the delay of other less essential payments might also force other institutions to delay their own settlements and cause many banks to manage increased uncertainty about their overnight funding needs

needs and of sources available. For this reason, banks have moved from static measures (like balance sheet ratios) towards forward-looking metrics, including cash flow projections and multiple scenario modelling[19].

In the light of above, the mixed maturity ladder only takes into account of expected cash flows on going concern basis; this approach allows to assess each on- and off-balance sheet account, including the effect of options embedded in the bank sources and uses of funds, and makes possible to determine how such position can affect or is affected by operational and contingent liquidity risk. Since a bank's future liquidity position is generally affected by factors that cannot always be accurately forecast, behavioural assumptions need to be made about the amount and timing of specific asset and liabilities cash flows mapped into the maturity ladder [20].

4.1. Cash Flow Modelling

There are different sources of uncertainty producing unexpected cash flows. The ambiguity can stem from three main types of *'liquidity optionality'*:

- *'no liquidity option'* – both counterparty and bank must each meet the contractual payments as they come due;
- *'short (passive) liquidity option'* – the bank must accept the counterparty's decision to exercise this option (the counterparty can, for example withdraw savings deposits and call an additional loan tranche);
- *'long (active) liquidity option'* – the bank itself can exercise this option, for example, call on a liquidity facility, sell a bond against cash, etc.

Bearing in mind the above liquidity options, all cash flows are grouped into four categories, depending on whether the nature of the amount and the timing of cash flows is 'deterministic' or 'stochastic' (table 7). Those are two dimensions that explain why liquidity risk management can be quite complex. When certain, cash flows can be predicted with confidence and easily mapped into the maturity ladder; when an uncertainty component is introduced, the degree of confidence declines and an accurate ranking becomes more complicated (table 7).

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[19] Prudent liquidity risk management requires the understanding of a bank's cash profile path in normal markets as well as the margins of a bank's cash position in a stressful environment.

[20] On the assets side, there is some ambiguity on the volume of new requests for loans (or renewal of old loans) that a bank will receive in the future. On the liability side, there is obviously a large uncertainty on the amount of deposit withdrawals (including wholesale) or the renewal of rolled-over inter-bank loans. This is especially true when the bank is under suspicion of insolvency, when there is a temporary (aggregate) liquidity shortage or when the economy suffers from a macroeconomic shock. It is important to underline that assumptions on a rollover rate for funding should be made before including ongoing new business . In order not to add further unpredictability to cash flow modelling, a lot of banks consider a "*pure run-off gap profile*" without new loans and rolled over funding transactions. Off-balance sheet operations are a third source of liquidity risk for banks, namely credit lines and other commitments. More importantly, the banks exposure on derivative markets can generate huge liquidity needs during crisis periods. A final source of liquidity risk are large value inter-bank payments, for which Central Banks prefer the use of Real Time Gross Settlement Systems (RTGSs) to Deferred Net Settlement (DNSs), because they are less prone to systemic risk. However, RGTSs are highly liquidity intensive and can only function properly if banks hold sufficient amount of collateral to back credit lines, either from the Central Bank or from other participants. The failure of a large participant in a large value payment system (LVPS) could provoke a big disruption to the financial system. Even a liquidity shortage due to a temporary halt in the payment activity of a large bank could have dramatic consequences. This creates a "too big to fail" issue since it is likely that the Central Bank is forced to intervene in such a situation.

Table 7:   Cash flow modelling according to a maturity-volume matrix

Cash flow timing:		
Deterministic	Fixed rate term loans & mortgages Cash/repos/collateralized lending Term deposits Fixed coupon payments (loans, bonds, IRS) Notional exchange from CCS	Variation margins European options Non-fixed coupons (loans, bonds, IRS) Dividends
Stochastic	Traveller's cheques Callable bonds Loan with flexible amortization schedule	Revolving loans Current accounts Sight & saving deposits Marketable assets (bonds, equities, funds) American options
	Cash flow amount:	
	Deterministic	Stochastic

Source: Neu (2007)

Expected cash flows (*ECF*), stemming from a 'non-liquidity option', show different grades of ambiguity. For example, consider term deposits, fixed with respect to maturity and rate, and securities (and coupons). Both dimensions are certain (i.e. amount and timing), meaning there is no unpredictability regarding the magnitude or timing of cash outflows. Whereas the cash flow mapping of these items only requires an appropriate data infrastructure that provides the correct balance sheet position [21], the measurement of other types of assets and liabilities' cash flows – e.g. with uncertain maturities – is performed using additional model assumptions and behavioural adjustments (table 8).

Table 8:   Key variables in cash flows modelling for specific assets and liabilities

Assets/Liabilities	Key variables
Loans	Residual maturity
Term deposits	Residual maturity
Securities	Liquidation period
Committed credit lines	Short-term contingent outflows
Guarantees	Short-term contingent outflows
Non Maturing Assets and Liabilities (NoMALs)	Behavioural maturities.

a). Securities
All banks hold some pool of assets available to sell in the event of a severe funding liquidity need. Liquidity risk for securities depends on how marketable securities are or on their ability to generate cash directly or trough a loan quickly. In order to provide a buffer related to the sales or pledge value of assets, banks measure and then apply a discount (i.e. haircut) to the value of financial assets, in order to minimize the probability of a shortfall. The haircut size reflects the perceived risk associated with holding the assets and can be adjusted in response to changes in market appetite (graph 4).

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[21] For example, loans can be modelled according to the coupon amortization schedule while issued plain vanilla bonds are modelled according to residual maturity.

Graph 4: Relationship between haircuts and bank risk tolerance
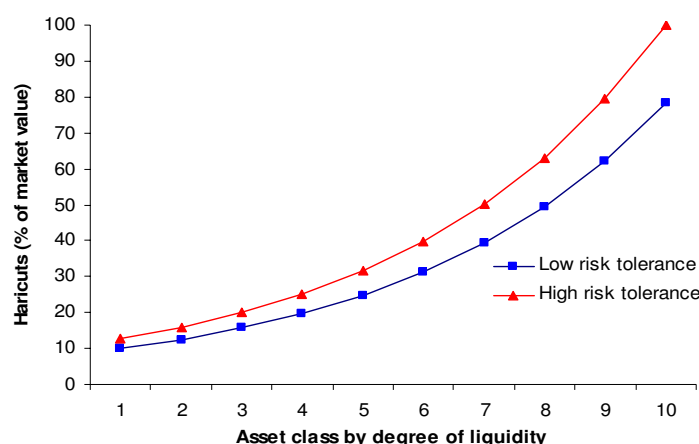
Rough indicators of the underlying liquidity of the assets, the haircuts can be measured in various way, but most frequently they are a percentage based on asset and quality type, with a specific focus on price volatility of the assets [22], liquidation horizon [23] and degree to which the asset can be sold or pledged [24]. As a matter of fact, from a liquidity risk perspective, usual interest rate risk measurements (i.e. duration) or contractual maturities are generally inappropriate tools.

The valuation of haircut is based on several criteria: ECB eligibility, position size, rating (high yield *versus* investment grade), issuer group (OECD, G7, emerging markets), issuer type (government, bank, corporate), listing location, currency, own position relative to outstanding volume, degree of structuring (plain vanilla *versus* structured product), and so on.

The size of the haircut applied by European Central Bank (ECB) to all securities offered as collateral depends on the risk level of the security itself. Here below, we show the haircuts used for residential mortgages and securities by Moody's (table 9).

Table 9: An example of Moody's haircuts used for residential mortgages and securities.

Liquid Assets	Haircuts
US Government securities	2%
US municipal securities	10%
US agency and GSE mortgage backed securities	10%
Equity securities	15%
Residential mortgages	20%
Debt securities including foreign debt	33%
Collateralized mortgage obligations and other	100%

Source: Moody's (2001)

b). NoMALs

Non-maturing assets and liabilities (*NoMALs*) are items in the bank's balance with no contractual maturity. They represent a question mark for banks as far as liquidity, because the cash inflow and outflow related to such items are not certain, but can be estimated by using different techniques.

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[22] The greater the volatility of an asset, the larger is its haircut. Price volatility, in turn, might be directly or indirectly influenced by deepness, tightness and resiliency of the market. Those markets that are deeper, tighter and more resilient can absorb a greater amount of activity without much remarkable price impact (e.g. change in the quoted mid-market price).

[23] The longer the time available for liquidation the smaller is the haircut.

[24] The ability to pledge securities taken as collateral in a financing transaction can also influence the level of the haircut. When they are used as collateral, securities will generally be devalued since a cushion is required by the lending parties in case the market value falls.

Typical examples of *NoMALs* include savings and sight deposits on the liability side of the balance, as well as credit card loans or variable-rate mortgages on the asset side.

Clients may exercise embedded options to add or withdraw investments or credits at no (or negligible) penalty. On the other hand, banks may adjust the customer rate anytime as a matter of policy. It is frequently observed that the volume of *NoMALs* fluctuates significantly as clients react to changes in the customer rate or to the relative attractiveness of alternative investment opportunities. For instance, when interest rates are low, clients are likely to switch to fix-rate mortgages in order to hedge themselves against a future rise (prepayment) while the deposit rate becomes more profitable compared to alternative short-term investments which attracts additional savings volume. Since the volume of the variable positions on both sides of the balance sheet fluctuates and is 'phase-delayed', mortgages (or other non-maturing loans) cannot be funded completely by deposits (graph 5).

Unlike the interest rate risk associated with fixed income instruments, the incomplete adjustment of the client rate to money and capital market rates cannot be hedged directly, since the volume is not traded in the market. Hence, conventional hedging techniques, like duration matching, can only be applied making supplementary assumptions about the quantity and timing of (future) cash flows. A fix maturity structure must therefore be assigned to the *NoMALs* in order to convert the uncertain cash flows into (apparently) certain ones.

There are other manners in which uncertainty can be modelled: stress scenarios, historical approaches or judgement-based methods, and so on. The assumptions on assets and liabilities with uncertain cash flows and the availability of alternative sources of funds during times of liquidity stress are of particular importance. Hypothesis about the market liquidity of assets, liabilities and off-balance sheet positions should be adjusted according to the market scenario or institution specific circumstances.

As to the historical approaches or judgement-based methods, the two most renowned classes of models are the *replicating portfolio* and the *option-adjusted spreads* (OAS) models. Their calibration and the derivation are frequently performed by statistical modelling, historical patterns or judgemental projections[25].

Is there any approach better than others? As described thereafter, both models lead to different measures and risk management decisions: OAS models are very flexible compared to the standard replicating portfolio approach. However, standard replicating portfolio is less computational intensive and very cheap in term of storage demand. However, the OAS model give the impression to be the simplest to maintain, because of, for example, the replication portfolio require continuous rebalancing of all instruments along the trend function assumed. Therefore, the answer to the previous question must be: '*the model choice depends on the specific situation*'.

4.2. Replicating Portfolio Models

The replicating portfolio approach aims to convert *NoMALs* into a portfolio of simple plain vanilla instruments – such as money market instruments and liquid coupon bonds - which are traded in highly liquid market and exhibit analogous features. Maturing plain vanilla instruments are always renewed at the same maturity, except for volume changes which are compensated by buying additional or selling existing tranches of the specified instruments.

The construction of a replicating portfolio model can be implemented in two manner: static or dynamic. The former methodology is more practical to put into practice and less computationally intensive. The *static approach* requires assuming a trend, an ample set of historical data of client rates, volumes and (reinvesting or financing) market rates that may be used for (e.g. the last five years). The portfolio composition is then established under the hypothesis that the cash flows of the (fixed income) instruments used for replication match those of the *NoMALs*, except for a certain margin, as close as

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[25] Usually statistical methodologies use mathematical frameworks of extreme events to calculate the maximum cash outflows for a given probability based on time series, whereas historical patterns are based on market observations (for assumptions on asset liquidity) or observations of bank business or other market participants.

possible; that is, the average yield on the portfolio shifts parallel to the client rate, and a fall in volume is balanced by maturing instruments (Frauendorfer and Schurle, 2007). This model aims at a minimization of the margin's volatility, and an estimate for its expectation may be often obtained from the average of the sample period achieved by a minimization of the tracking error between the cash flows payments of the portfolio and the underlying *NoMALs* position. The assumed (linear) trend function is typically estimated with regression techniques [26] if sufficient historical data applicable to current situation are accessible.

A typical linear trend structure could be (Bardenhewer, 2007):

$$V_t = \beta_0 + \beta_1 \cdot \Delta_t + \sum_i \beta_2 \cdot (r_{i,t} - \bar{r}_i) + \beta_3 \cdot (cr_t - \overline{cr}) + \varepsilon_t$$

where i is the maturity of buckets (i.e in months), V_t is the total volume at time t, $r_{i,t}$ is the interest rate with maturity i at time t, $\bar{r}_i$ is the average interest rate with maturity i over estimation period, cr_t is the customer's rate at time t, $\overline{cr}$ is the average customer's rate over estimation period, Δ_t is the time (i.e in months) between time 0 and t, ε_t is the residual at time t, and $\beta_0, \beta_1, \beta_2, \beta_3$ are parameters to be estimated using the simple ordinary least squares (OLS) techniques or other robust approaches.

Once specified the trend function, the weights of the buckets are determined such that the yield of replicating portfolio mimics the rate of *NoMALs* plus (or minus) a fixed spread during the estimation period. The resulting *'optimal weights'*, whose sum must equal to one, are invariable over time and are chosen in order to minimize the volatility of spread between the yield of the replicating portfolio and the position with uncertain maturity (Table 10).

To reduce the implied limit of the weight's constancy, the cash flows modelling of indeterminate maturing products is given by an estimation of the stable (or *'core level'*) and volatile part of the current balance. The former fraction is assigned to first time buckets of a maturity ladder (e.g. from overnight up to 1 month)[27].

However, this estimation has two main drawbacks: it excludes adjustments of the weights in the future (weights are never adjusted) and assumes that interest rates evolve in the future as they did in the past (no source of randomness is represented). An example of static replication is represented in graph 5.

Graph 5: Replicating portfolio with 3 rolling tranches: static replication

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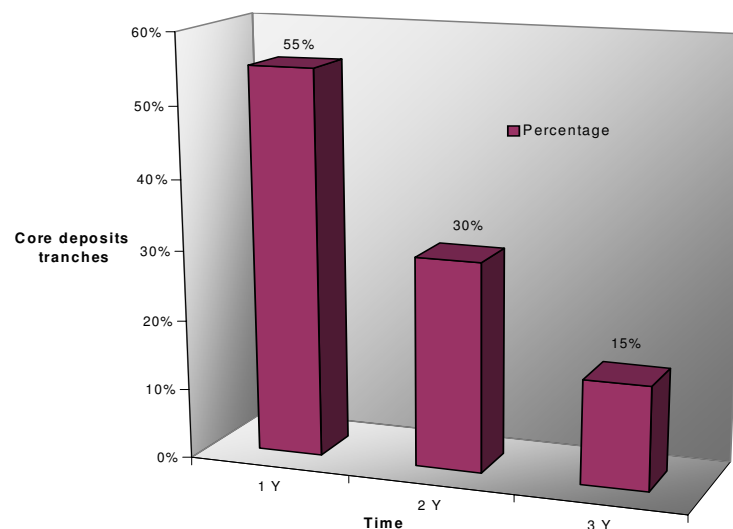
[26] Using, for example, the simply ordinary least square (OLS) approach.
[27] The same applies to other items, as commitment in revolving loans or committed credit lines.

Table 10:   Run-off vectors: weights

| w(1)	w(2)	w(3)
25%	0%	0%
30%/2	30%/2	0%
45%/3	45%/3	45%/3

Source: Behrens (2006)

Instead of making use of the times series of asset and liabilities with uncertain maturities, the *dynamic approach* takes into account the conditional probability distributions (expressed by a set of scenarios) of the future risk factors [28] - using a multistage programming techniques – and satisfies some criterion in order to obtain the optimal allocation of the new tranches for a given time horizons. The optimality is identified in the minimization of the tracking error and maximization of margin subject to risk limits. For each scenario, the weight at which new tranches are allocated are subject to adjustments in order to minimize the expected downside deviations.

4.3. Option Adjusted Spread Models

The Option Adjusted Spread (OAS) models have a different starting point compared to replicating portfolio models. In this case, term structure models are used to apply option pricing theory to *NoMALs*. The embedded options - that clients may exercise to add or withdraw their funds at any time - are explicitly considered throughout models for the evolution of the customers' rate and the volume of the *NoMALs*. The embedded option value is part of the present value of the non maturing product, or added or subtracted implicitly as a spread to its coupon.

One of the most powerful and popular first arbitrage-free approaches for the valuation of the demand deposits and credit card loans is provided by the Jarrow-van Deventer (called hereafter JvD) framework [29]. According to this valuation model, the net present value of a deposit results from the term structure of interest rates, the bank's choice on the rates paid to customers and, consequently from the clients' behaviour in terms of volume growth. Thus, the three key components of the traditional OAS models are: volume growth, rates paid to customers and a interest rate term structure (Graph 6).

Graph 6: Mechanism of an OAS model
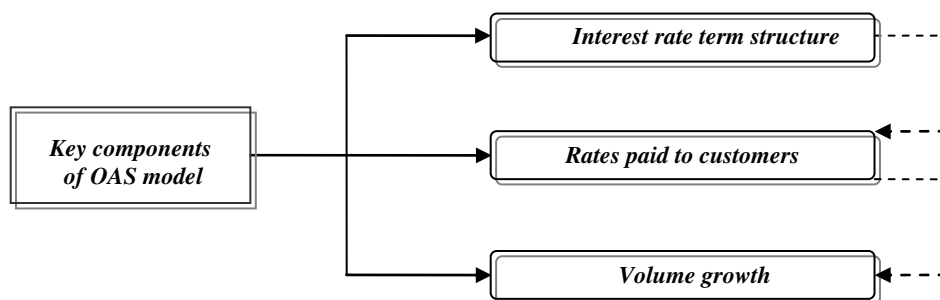
First arbitrage-free and equilibrium models like this are often based on simplifying assumptions for the number and type of underlying risk factor processes and, in particular, for the dependencies between client rate, volume and market rates to derive closed form solutions of the corresponding pricing equations.

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[28] For example, interest rates, customers' rates, current volumes, etc.

[29] This approach is consistent with the pricing and risk management of traded products. In their paper, JvD show how the risky position may be hedged by a replicating portfolio that results from investing and financing in fixed income securities.

The contribution of JvD paper is to provide an arbitrage-free procedure in order to compute present values in a stochastic interest rate environment using the Heath, Jarrow and Morton (HJM) forward rate methodology [30].

In its traditional form, the net present value of a deposit is positive if the remuneration rate is mostly lower than the market interest rate, that is, if the deposit spread is globally positive. To justify the differences between market rates and rates charged on demand deposits or credit card loans, a 'market segmentation' argument is used [31]. Thus, there are two types of agents [32]:

1. the banks and financial institutions that unilaterally fix the level of the deposit rate (i_t);
2. individual investors that have a 'one-period liquidity option': they can withdraw their deposit balance at the end of each period (D_{T-1}) and can reinvest their funds at the beginning of the next one ($+D_T$). The remuneration is paid at the end of each period (t) depending on the rate set at the beginning of that period (i_{t-1}) (Table 11).

Table 11: Cash flow stream of the deposit account (JvD case)

T	0	1	2	...	T-1	T
Addition	$+D_0$	$+D_1$	$+D_2$	...	$+D_{T-1}$	
Withdrawal		$-D_0$	$-D_1$	...	$-D_{T-2}$	$-D_{t-1}$
Interest		$-i_0 D_0$	$-i_1 D_1$	...	$-i_{T-2} D_{T-2}$	$-i_{T-1} D_{T-1}$
Balance	D_0	D_0	D_2	...	$+D_{T-1}$	0

Source: Jarrow and van-Deventer (1998)

As shown in the table above, for each period ($T-i$) the cash flows are equivalent to the amount put on the deposit account ($+D_{T-i}$), the amount removed ($+D_{T-i-1}$) and the remuneration paid to the deposit holder ($-i_{T-2} D_{T-i-2}$). Under the assumption that the deposit rate and the volume of the deposit depend only on the information on the money market, a risk neutral valuation procedure is used to compute the net present value of the deposit (NPV_{D_0}):

$$NPV_{D_0} = E_0 \left\{ \sum_{t=0}^{T-1} D_t (r_t - i_t) \Big/ B_{t+1} \right\} \text{ with } B_{t+1_0} = B_t (1 + r_t) \text{ and } B_{0_0} = 1$$

where B_{t+1_0} is the value of a money market account, r_t is the one period risk-free rate at period t and D_t is the value of the money market account used to discount the cash flows in a risk neutral world. NPV_{D_0} depends on the evolution of the deposit amounts and of the level of the deposit spread ($r_t - i_t$).

The OAS models include also a further specification of withdrawals (i.e. 'volume process'). To capture deposit rate behaviour for deposit valuation purposes, standard practice is to use a regression analysis relating deposit rates to a short-term market rate, e.g. a U.S. Treasury bill rate. Autoregressive specifications, such as partial adjustment, are used to capture deposit rate stickiness, as well as average market-deposit rate spreads:

$$w_t = \alpha_0 + \alpha_1 \cdot \bar{r}_{n,t-z} + \alpha_2 \cdot \bar{s}_{m,t-s}$$

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[30] Instead of modelling a short-term interest rate and deriving the forward rates (or, equivalently the yield curve), from that model, they start with a model for the whole forward rate curve. Since the forward rate curve is known at present, the matter of yield curve fitting is contained within their model.

[31] The market segmentation argument is that banks alone, and not individual investors, can issue demand deposits and credit card loans. In JvD model, both individual investors and banks can trade in frictionless and competitive Treasury security markets. Under this hypothesis, they show that demand deposits and credit card loans are equivalent to an exotic interest rate swap, where the principal amount depends on the past history of market rates. Both Hutchison and Pennacchi (1996) and Jarrow and van Deventer (1999) allow imperfect competition in the market for deposits. However, they assume perfect competition in lending markets. This assumption leads them to conclude that deposits should be valued according to the Treasury rate of the same maturity (JvD make this assumption explicit in their appendix). However, if deposit and loan markets are both characterized by imperfect competition, their results must be modified.

[32] The division between these two types of traders is based on their ability to issue demand deposits and credit card loans.

where w_t are withdrawals in t and $\alpha_0, \alpha_1, \alpha_2$ are estimated parameters.

The client rate in the original JvD model is a deterministic function of the short rate as the only source of uncertainty. Therefore, the bank's option to set the rate is driven by market interest rates, either directly or indirectly through customer's behaviour. The client rate is not always equal to the short rate. However, deposit rates and balances are rather slow-moving and often do not respond instantly to changes in the return on alternative investments, such as the money market rate. To reflect the typical stickiness of depositor rates, the model incorporates some time lags. Typically, the rate paid to the client (the savings rate) is set by the bank and the balance is determined by client behaviour. The customers' rate (cr_t) is supposed to depend not on current market rates but on market rates observed in the past [33]:

$$cr_t = \gamma_0 + \gamma_1 \cdot \bar{e}_{n,t-z} + \gamma_2 \cdot \bar{s}_{m.t-z}$$

where $\bar{e}_{n,t-z}$ is the average of n months money market rate over the last z months (e.g. 1 month Euribor over the last 6 months), $\bar{e}_{n,t-z}$ is the average of m years swap rate over the last z months and $\gamma_0, \gamma_1, \gamma_2$ are parameters estimated from historical data.

4.4. An Alternative: the 'worst case run-off profile' model for *NoMALs*

The relationship between non-maturing asset or liabilities and market rates is not often particularly comprehensible in some markets also because of resiliency. For example, banking institutions may find varying levels of sensitivity of depositors which will make it difficult to predict volume response. The volume growth changes with market characteristics, bank size or geographical region, regulation as well as money market conditions. In some markets, deposit volume reacts significantly to interest rate differentials, while in others the deposits are insensitive to small differentials.

Analysing Italian market, banks offer a variety of financial products to their retail customers, including mortgages and home equity loans, credit cards, and several different types of deposit accounts. For most retail loan products, prices depend on customer-specific characteristics, such as credit rating and income, which cannot easily be observed. In contrast, interest rates and fees for deposit products do not generally reflect customer-specific characteristics. For example, empirical evidences given by Bruno and De Bonis (2000) show how market concentration could be an important factor influencing banks' interest rates [34].

In the light of complexity of the former statistical tools, we have reviewed and took into consideration the above mentioned resiliency. We propose a simpler mathematical framework of extreme events to calculate the maximum cash outflow for a *NoMALs*, such as for customer's sight deposits, for a given probability based on a history of data (e.g. used to determine a *'worst case run-off profile'*). We try to make an estimation of the stable (the so called 'core level') and volatile fraction of current balance. The core quantity can be defined as the balance amount that will not withdraw within the first T months (e.g. 6 months) or, in other words, as the lower barrier that is not crossed with a probability q within T months:

$$\Pr ob(V_T(q) \leq Core\_balance) = 1 - q$$

In our equation, the core level of customer's sight deposits with a confidence level cl $(= q)$ over a certain time horizon, t, is modelled as long-term outflows through log-normal diffusion process[35]:

$$Core\_level = \log V_t = \alpha + \beta \cdot t - \sigma \sqrt{t} \cdot \Phi^{-1}(cl)$$

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[33] From the bank's point of view, the level of the deposit rate is set either to achieve a certain margin (see Selvaggio (1996)) or to maximise the profit (Hutchison and Pennacchi (1996)).

[34] Bruno and De Bonis (2000) compares alternative econometric packages by analyzing the determinants of deposit interest rates in the Italian banking system. They consider the influence on interest rates of the Herfindahl index, the concentration ratio for the first three banks in the province, the number of banks in each province, the growth rate of deposits, the ratio between banking costs and total assets, and average staff costs per employee.

[35] The greater is the confidence interval, cl, the higher are $\Phi^{-1}(cl)$ and – other things equal – the volatile fraction.

where α and β being computed from a linear regression on the historical deposit account time series, ε_t is a Gaussian noise term (standard normally distributed random number), $\Phi^{-1}(x)$ is the inverse cumulative normal distribution, σ is the volatility of the historical balance sheet time series. Consequently, the 'core-level' (V_t) amount is derived by setting $\alpha = \log V_0$ (V_0 is the current balance of customer's sight deposits) and $t = 1$ (e.g. 1 month) and using a regression model based on historical drift and volatility of deposit balance.

As a matter of fact, under the assumption that the current value of *NoMALs*, V_t, is lognormally distributed and the geometric return of *NoMALs*, R_t[36]:

$$R_t = \log V_t - \log V_{t-1} = \log \frac{V_t}{V_{t-1}}$$

is normally distributed with mean μ_R and standard deviation σ_R, we have begun deriving the critical value of the deposit growth (R_t), R^*, for a given confidence level, *cl*, based on a counterparty names' concentration ratio (i.e. the Herfindahl index):

$$R^* = \mu_R + \alpha_{cl}\sigma_R$$

We then have used the definition of the geometric return to find the critical value V^* (i.e. the value corresponding to the core *NoMALs* amount), and thence inferred the volatile fraction of *NoMALs* $\Delta_{NOMALs,t}$:

$$R^* = \log V^* - \log V_{t-1} \Rightarrow \log V^* = R^* + \log V_{t-1}$$
$$\Rightarrow V^* = \exp\left[R^* + \log V_{t-1}\right] = \exp\left[\mu_R + \alpha_{cl}\varpi_R + \log V_{t-1}\right]$$
$$\Rightarrow \Delta_{NOMALs,t} = V_{t-1} - \exp\left[\mu_R t + \alpha_{cl}\sigma_R \sqrt{t} + \log V_{t-1}\right]$$

where $\mu_R = \beta$ and $\alpha_{cl} = \Phi^{-1}(cl)$.

First, the core balance position is determined; then, the volatile part is defined as balance account minus core part. The volatile amount is put into overnight time bucket, while the core is subdivided into portions which are invested in different time bands. In each period rolling balances are reinvested in the same time band (Table 12).

**Table 12:** Core deposit amount for different time buckets

$t = 0$	V_0
$t = 1$	$\log V_1 = \log V_0 + \beta \cdot 1 - \sigma \cdot \Phi^{-1}(q)\sqrt{1}$
$t = 2$	$\log V_2 = \log V_0 + 2 \cdot \beta - \sqrt{2} \cdot \sigma \cdot \Phi^{-1}(q)$
...	
$t = n$	$\log V_{n2} = \log V_0 + n \cdot \beta - \sqrt{n} \cdot \sigma \cdot \Phi^{-1}(q)$

Here below we present the smoothing output of this model obtained using monthly data of sight deposits volume from the whole Italian banking system for the period January 2004 to May 2008 (graphs 7 and 8).

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[36] The lognormal assumption has the attraction of ruling out the possibility of negative value for *NoMALs*; as the holding period continues to rise, the mean becomes more important than the standard deviation term because it grows at a faster rate.

Graph 7: Term structure of the Italian banking system core deposits at the date of 31/05/2008
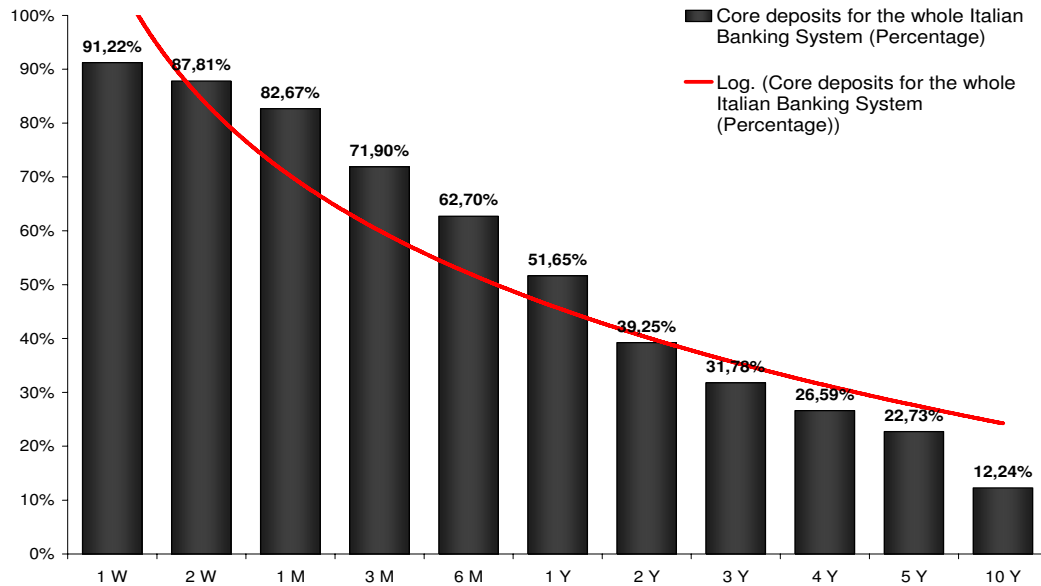
Source: own estimation.

Graph 8: Evolution of the Italian banking system core deposits from 30/09/2007 to 31/05/2008
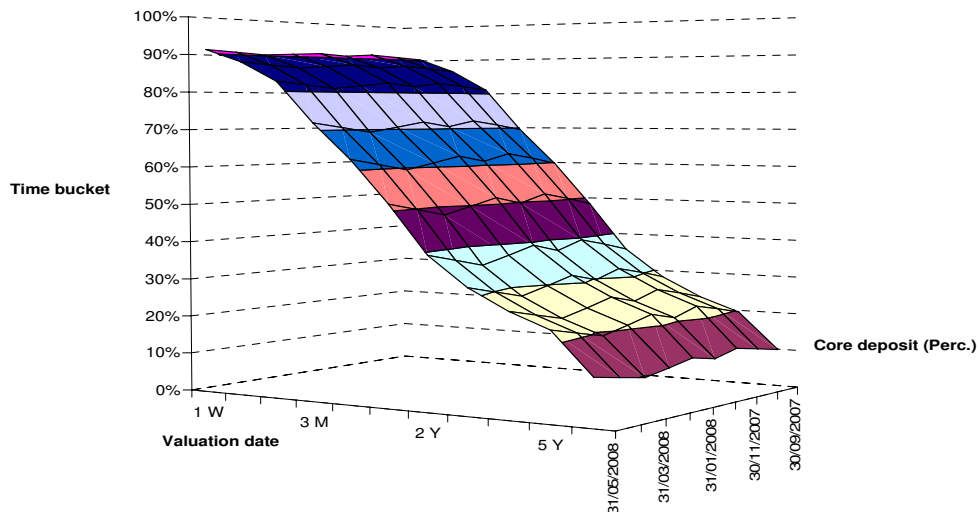
Source: own estimation.

4.5. Liquidity adjusted Value at Risk (LaR)

If we concentrate on both illiquidity risk (i.e. a impossibility to fulfil contractual obligations) and P&L risks (i.e. the disability to compensate cash shortage or surplus at market price), it becomes essential to:

- identify the *'structural liquidity risk'*, that is the risk the bank has in balance sheet structure due to maturity transformation;
- evaluate *'extended liquidity risk'*, arising from adverse changes in projected position as well as to the estimated counterbalancing capacity.

The two above mentioned definitions of liquidity risk are embraced in the Liquidity adjusted Value at Risk (*LaR*). This risk measure – sometimes also known as '*cash flow at risk (CFaR)*' can be defined as the maximum loss, stemming from '*unwanted liquidity situations*' (caused by unpredictable

counterparties' options and market variables' changes) not exceeded with a given probability, defined as the confidence level, over a given period of time[37].

In the LaR framework, the bank's expected liquidity profile is adjusted to manage potential changes of expected cash flows (ECF). The ECF contains deterministic cash flows (ECF_D) and volatile cash flows (ECF_{ND}) (Table 13). ECF_D are very easy to handle because we know them in advance (e.g. income from government bonds, etc.). On the other hand, ECF_{ND} include:

- floating cash flows (ECF_F) depending on the market indices (i.e. Euribor index, exchange cross rate, etc.);
- virtual cash flows (ECF_V), that is the discrepancy between the estimates of ex-post cash flows and their original projections (short optionality) and
- hypothetical cash flows (ECF_H) connected with unknown new business (long optionality).

$$ECF(t) = ECF_D + ECF_{ND} = ECF_D + (ECF_F + ECF_V + ECF_H)$$

Table 13: Decomposition of expected cash flows (ECF)

Cash Flows Stemming from all Contractual			Cash Flows Originating by New Business
Known Cash Flows CF	Floating Cash Flows ECF_F	Virtual Cash Flows ECF_V	Hypothetical Cash Flows ECF_H
Deterministic cash flows ECF_D	Volatile Cash Flows ECF_{ND}		

Source: Fiedler (2007)

The forward liquidity exposure (*FLE*), prognosis of future liquidity situations, is given by the sum of positive (ECF^+) negative (ECF^+) expected cash flow from one day to the whole time horizon (table 14).

Table 14: An example of Forward Liquidity Exposure (FLE)

Date	ECF⁺	ECF⁻	ECF	FLE
O/N	50,64	-32,85	17,79	17,79
T/N	60,35	-15,33	45,02	62,81
S/N	15,87	-36,43	-20,56	42,25
1 w	30,25	-42,37	-12,12	30,13
2 w	37,04	-52,65	-15,61	14,52
1 m	42,53	-40,64	1,89	16,41
2 m	19,76	-25,84	-6,08	10,33
3 m	25,37	-22,89	2,48	12,81
6 m	21,58	-28,74	-7,16	5,65
1 y	33,24	-40,28	-7,04	-1,39
3 y	21,24	-28,59	-7,35	-8,74
5 y	50,68	-41,36	9,32	0,58
10 y	36,84	-25,85	10,99	11,57
30y	45,95	-39,41	6,54	18,11
> 30 y	72,55	-39,5	33,05	44,62

LaR measure try to capture both insolvency risk - that is impossibility to fulfil contractual obligations - and liquidity induced P&L risk, disability to compensate cash shortage or surplus at current market price:

$$FLE(t) - LaR_q(t) + CBC(t) \geq 0$$

where:

---

[37] The LaR is the cash flow equivalent to the VaR, but whereas VaR deals with the risk of losses (or profits), LaR deals with the risk of cash outflows. Thus, the LaR can be lower or higher than VaR, because the former depends on the larger gross position, whilst the latter depends on the larger net position (Dowd, 2002).

- $FLE(t)$ is the (cumulated) forward liquidity exposure at t:

$$FLE(t) = FLE(0) + \sum_t ECF(t-1) - \sum_t LaR(t-1)$$

- $CBC(t)$ is the counterbalancing capacity: it measures a bank's ability to fund the potential liquidity shortfalls from its own resources. On the other hand, CBC is divided into three components:
  - (i) new liabilities in the form of non secured funding, F, (e.g. additional borrowing, issuing new debt);
  - (ii) balance sheet neutral sale/repurchase of assets, R (e.g. liquidity by repos) and
  - (iii) selling assets, S

$$CBC(t) = F(t) + S(t) + R(t)$$

- and $LaR(t)$ is the liquidity at risk with a q-confidence level such as:

$$CFaR(t)^- \le CF \le CFaR(t)^+$$

where $CFaR(t)^-$ is the lower quantile and $CFaR(t)^+$ is the upper quantile of cash flows distribution. For insolvency risk only $CFaR(t)^-$ is relevant. However, for the second degree of liquidity risk also $CFaR(t)^+$ is needed (graph 9 and table 15).
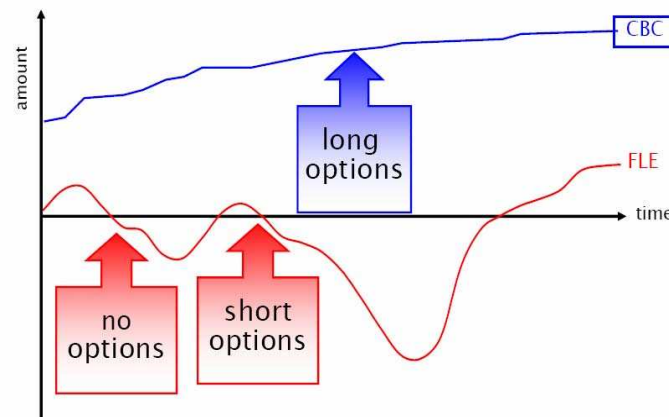
Graph 9: Liquidity status

Table 15:   An example of Value LaR

| years =now	par p	fwd f	funding		stressed		position	costs		
			s	f+s	σ	f+s+σ	FLE	f+s	f+s+σ	delta
1	3,74%	3,74%	0,08%	3,82%	0,04%	3,86%	−22,30	−0,85	−0,86	−0,0089
2	4,03%	4,04%	0,10%	4,14%	0,10%	4,14%	17,40	0,70	0,70	0,0000
3	4,29%	4,31%	0,12%	4,43%	0,16%	4,47%	22,43	0,97	0,97	0,0000
4	4,50%	4,53%	0,14%	4,67%	0,22%	4,75%	−18,33	−0,86	−0,87	−0,0147
5	4,68%	4,72%	0,16%	4,88%	0,28%	5,00%	−5,39	−0,26	−0,27	−0,0065
6	4,84%	4,90%	0,18%	5,08%	0,34%	5,24%	−17,41	−0,88	−0,91	−0,0279
7	4,97%	5,04%	0,20%	5,24%	0,40%	5,44%	9,91	0,50	0,50	0,0000
8	5,08%	5,17%	0,22%	5,39%	0,46%	5,63%	7,88	0,41	0,41	0,0000
9	5,19%	5,29%	0,24%	5,53%	0,52%	5,81%	−3,54	−0,20	−0,21	−0,0099
10	5,28%	5,40%	0,26%	5,66%	0,58%	5,98%	−10,77	−0,61	−0,64	−0,0345
									Sum	−0,1023

Source: Fiedler (2007)

5. Incorporating Market Liquidity Risk into VaR Models: the Liquidity VaR (LVaR)

Another face of liquidity risk is market risk. It should be noted that the standard Value at Risk (VaR) models are typically based on the assumption of normal markets and are not well suited for stress management [38]. Even if regulators in many countries require banks to use VaR models, these market risk quantification processes contain several fundamental imperfections: (i) no estimate of tail risks and losses, (ii) difficulties identifying the non-linear pay-offs characteristics of many complex and structured products, (iii) no consistent method of aggregating risks across different asset classes, (iv) concentration on the distribution of portfolio value changes resulting from movements in the mid-price of each assets and (v) separate modelling of asset prices and portfolio size, among others.

As shown in Bangia *et al*. (1999), conventional VaR methodology does not distinguish between market risk and liquidity risk, because historical market prices are supposed to embrace latent liquidity effects (graph 10).

Graph 10: Combining market and liquidity risk into VaR framework
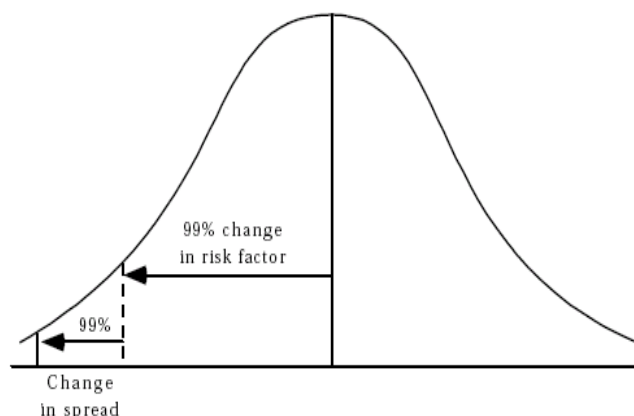
Source: Bangia et al. (1999)

VaR model assumes ideal conditions as to the unwinding of the position with one trade at a predetermined market price, equal to the current quoted mid-price, within a fixed period of time (usually one trading day), not considering of the size of the position. In this circumstance, the market risk is really considered in a 'pure' form, with no 'frictions'. However, as a flow of sales exceeds the depth of the available best quotes, the bid-ask spread increases; in this circumstances the mid-price used for market risk estimates become progressively more inadequate.

The degree of liquidity of the market for a financial asset (or a portfolio of financial assets) is linked to a variety of factors, including: outstanding size, relative size, frequency and modalities of transactions, number and quality of market participants, relevance of transactions costs, amount and quality of information on prices, traded volumes, security type and, more fundamentally, the credit-worthiness of the issuer [39].

In order to account for the a variety of factors responsible of divergences of liquidation price from the mid-quote, quite a few methods have been proposed to incorporate market liquidity and transaction costs into the VaR measurement framework. These methods will be briefly surveyed hereafter.

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[38] Furthermore, the change of economic factors and the customer's reaction to it can be different from the past.

[39] For example, markets can vary deeply in their liquidity due to a number of factors such as the number of traders in the market, the frequency and the volume of trades, the time it takes to carry out a negotiation and the cost of transacting.

a). Empirical Adjustments

The simplest approach is to estimate n-day VaR that takes advantages of an asset-specific liquidation horizon (T_i):

$$T_i = \max(n, m_i)$$

where m_i is the number of days to liquidate net position in the assets i. The key features of m_i are position size [40] and asset mix [41].

A second possible approach consists in artificially increasing volatilities for illiquid assets. Standard VaR is then calculated on a modified variance-covariance matrix. Volatility add-ons are subjectively specified. Also this approach has some relevant limitations. Particularly, it gives no guidance on how to quantify corrections to volatility and it is not focused on the problem of liquidity risk.

b). Adjustments Based on Quoted Spread: The Transactions Cost Approach

Assuming the bid-ask spread (*BAS*) as main source of liquidity costs, more complex *LVaR* approaches make use of adjustments based on current (or expected) value or on quantiles of *BAS* distribution. If we assume that a position can be smoothly closed at quoted prices, execution costs can be approximated as a function (i.e. linear, exponential, etc.) of current or expected bid-ask spread:

$$LVaR = VaR + PS \cdot \frac{E(S)}{2}$$

where *PS* is the position size, *E(S)* is the expected value of bid-ask spread controlled by traders [42]. Extending the previous methodology, it can be computed the liquidity component of *VaR* substituting a quantile, for a given probability, of the spread distribution for the current or expected value of the spread. This approach, presented in Erzegovesi (2002), adopts a worst-case estimate of liquidation costs with a given degree of confidence.

$$LVaR = VaR + PS \cdot \frac{Q_{S_j}(p)}{2}$$

where $Q_{S_j}(p)$ is the quantile function of the quoted spread distribution (i.e. the inverse function of the spread distribution function) and *p* the probability value at which *LVaR* is computed [43]. Only exogenous liquidity is considered; endogenous liquidity, in contrast, is not measured; the position size, the main factor affecting endogenous liquidity risk, does not enter the estimated cost of execution [44]. However, it can plausibly assume that transactions cost increase not only with the BAS but also with the size of the transaction compared to the market size for the instrument concerned (i.e. because of adverse market responses due to limited liquidity) and the length of time required to liquidate the position. An alternative approach, defined as the Transactions Cost Approach (*TCA*) by Dowd (2002), incorporates market liquidity and transaction costs into the VaR measurement framework. In this methodology, the transactions costs (*TC*) are a function of the position size (*PS*) compared to the market size (*MS*), the

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[40] Small positions have the same VaR contribution as before; on the other hand larger position have a larger liquidation horizon.

[41] Illiquid assets make a larger contribution to the Liquidity adjusted VaR than in "vanilla VaR".

[42] So, S/2 is the difference between the quoted mid-price and the actual transaction price.

[43] The spread quantile approach has one main advantage: it relies on observable market data, providing the risk control function with objective information that does not depend on estimates by traders.

[44] Exogenous illiquidity is the result of market characteristics; it is common to all market players and unaffected by the actions of any one participant while endogenous illiquidity is specific to one's position in the market, varies across market participants, and the exposure of any one participant is affected by her actions. It is mainly driven by the size of the position: the larger the size, the greater the endogenous illiquidity (see Bangia et al., 1999).

amount liquidated (*AL*) at the end of the holding period (*T*) [45], and λ_1 and λ_2, positive estimated parameters[46]:

$$TC = \left[1 + \frac{PS}{MS}\right]^{\lambda_1} \left(AL \cdot \frac{S}{2}\right) \cdot e^{-(\lambda_2 T)}$$

If we have a loss equal to Liquidity Value at Risk (*LVaR*), the amount liquidated at the end of the holding period will be equal to the initial position size minus the *LVaR (Graph 12)*:

$$TC = \left[1 + \frac{PS}{MS}\right]^{\lambda_1} \cdot \left(AL \cdot \frac{E(S)}{2}\right) \cdot e^{-(\lambda_2 \cdot T)} = \left[1 + \frac{PS}{MS}\right]^{\lambda_1} \cdot \left[(AL - LVaR) \cdot \frac{E(S)}{2}\right] \cdot e^{-(\lambda_2 \cdot T)}$$

Graph 11: The impact of holding period on LVaR ($E(S) = 0,05$; $\lambda_1 = 1$; $\lambda_2 = 0,1$; $PS / MS = 0,05$)
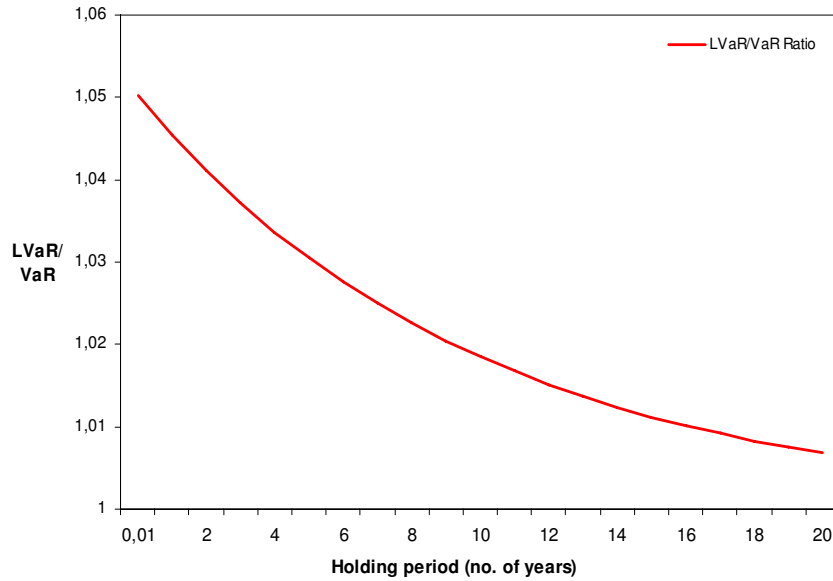
The *LVaR*, in turn, is equal to the Standard VaR (obtained in absence of transaction costs), plus the transactions costs themselves (Graph 12).

$$LVaR = VaR + TC = \frac{VaR + k \cdot PS}{1 + k}$$

where *k* can be read as a transactions cost rate:

$$k = \left[1 + \frac{PS}{MS}\right]^{\lambda_1} \cdot \left(\frac{E(S)}{2}\right) \cdot e^{-\lambda_2 \cdot T}$$

c). The Exogenous Spread Approach
An alternative approach is suggested by Bangia *et al.* (1999). They developed and illustrated a simple measure of exogenous liquidity risk, computed using mean and volatility of the distribution of observed bid-ask spreads. The LVaR is then given by:

$$LVaR = \left[1 + \left(\frac{\mu_s + \vartheta \cdot \sigma_s}{2}\right)\right] \cdot VaR$$

---

[45] The liquidation time horizon must be equal to the risk horizon used for market VaR. Increasing *T* leads to higher market VaR and lower liquidation costs.

[46] The parameters λ_1 and λ_2 are closely related correspondingly to the elasticity of *TC* with respect to relative position size, *PS/MS*, and the impact of *T*, measured in daily units, on *TC* (this is called "*time decay*").

where μ_s is the average *spread*, σ_s is the spread volatility multiplied by a scaling factor (ϑ) such that it can achieve a x% probability coverage. Because spread distributions could be very far from Gaussian, ϑ ranges depend on the instrument and market in question; generally speaking, the greater the departure from normality, the larger ϑ.

Asset liquidity cannot always be computed through bid-offer spreads or other measures of frictions (i.e., temporary price impact, etc.[47]). As we showed above, certain contracts lack sufficient turnover and/or fair value as a result of their structural complexity or particular features (i.e. *NoMALs*). It means that financial institutions must not rely on model to estimate value and liquidation prices.

Table 16: The main features of alternative approaches to liquidity VaR adjustment

Approach	Spread cost	Spread risk	Exogenous liquidity	Endogenous liquidity	Transaction cost	Variable holding period	Endogenous liquidation strategy
Transaction cost	Yes	No	Yes	Yes	Yes	Yes	Not really
Exogenous spread	Yes	Yes	Yes		Yes	Not really	No
Market price response	No	No	Not really	Yes	No	No	No
Derivative pricing	No	No	Not really	Yes	No	No	No
Liquidity discount	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Dowd (2002)

Other market liquidity risk models concern the optimal execution strategy in the presence of information asymmetry and its relationship with the behaviour of prices, derivatives pricing approaches that focus on the market's response to the trading of derivatives securities, the liquidity discount approaches that consider an optimal liquidation problem in the trading activity, and so on (Table 16).

6. Some Considerations on "Originate-to-Distribute" Business Model in the Context of Current Financial Turbulences

'The knowledge of the substantial changes in the borders of the financial systems it is helpful to understand where the sub-prime crisis came from'.

Over the last decade, a new global financial landscape has emerged as a result of considerable changes. Three are the main driving forces that have profoundly reshaped financial markets as well as the contour of liquidity environment. These broad factors reinforced one another in a way that almost nobody could have foreseen. Two of these are the *market integration* and complexity that has generated increased interdependence, '*spillover effects*' [48] and the financial globalisation [49]. The third broad driver of change is the interaction between *deregulation*, *technical progress* and *financial innovation*.

The elimination of some structural and regulatory barriers between investment banking and commercial banking has fostered competition within the financial system. Advances in technology, instead, spurred a wave of financial innovation and the development of new products offering improvements in the tailoring and matching of risks to investors' risk appetite. The principal role of

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[47] For a review of measures of frictions, see Erzegovesi (2006).

[48] Nowadays, shocks are transmitted more rapidly across borders through financial markets. On the other hand, financial integration has allowed greater risk diversification with a less exposure to country-specific shocks for investors holding global asset portfolios.

[49] Globalisation and economies of scale fostered cross-border markets and the consolidation of previously fragmented national markets, which has increased liquidity and lowered transaction costs in market-based finance.

financial innovation is to make markets more complete, so that corporate and financial firms, households and governments can better satisfy their more and more complex financing needs and share risk among each other.

This combination of factors encouraged investors to seek out riskier investments in search of higher returns. One feature of this 'search for yield' was the rapid expansion of structured financial products. Through techniques such as securitisation and re-securitisation of debt, financial innovation encouraged the commoditisation of assets.

The relentless growth of asset securitisation, which relies on complex financial instruments and on sophisticated risk management techniques, together with the expansion of credit derivatives, symbolizes the most important recent structural development in modern financial systems [50].

Fulfilled by high demand from investors stemming from the search for returns, in an environment of relatively low yields and diversification opportunities, the extraordinary broadening of lending-related assets securitisation has been also positively affected by the general move towards a more market-based financial system.

This trend has led to a fundamental shift in the business of banking from 'buy-and-hold' strategies to so-called 'originate-to-distribute' (OTD) models, by which banks (particularly those of large size) originate loans and then repackage them for sale to a pool of investors.

The steps underlying the production of a loan, such as a mortgage, are very complex and are usually divided into distinct activities and, in general, involve many different players (graph 12).

Graph 12: The range of some players and flows involved in a generic structured finance transaction
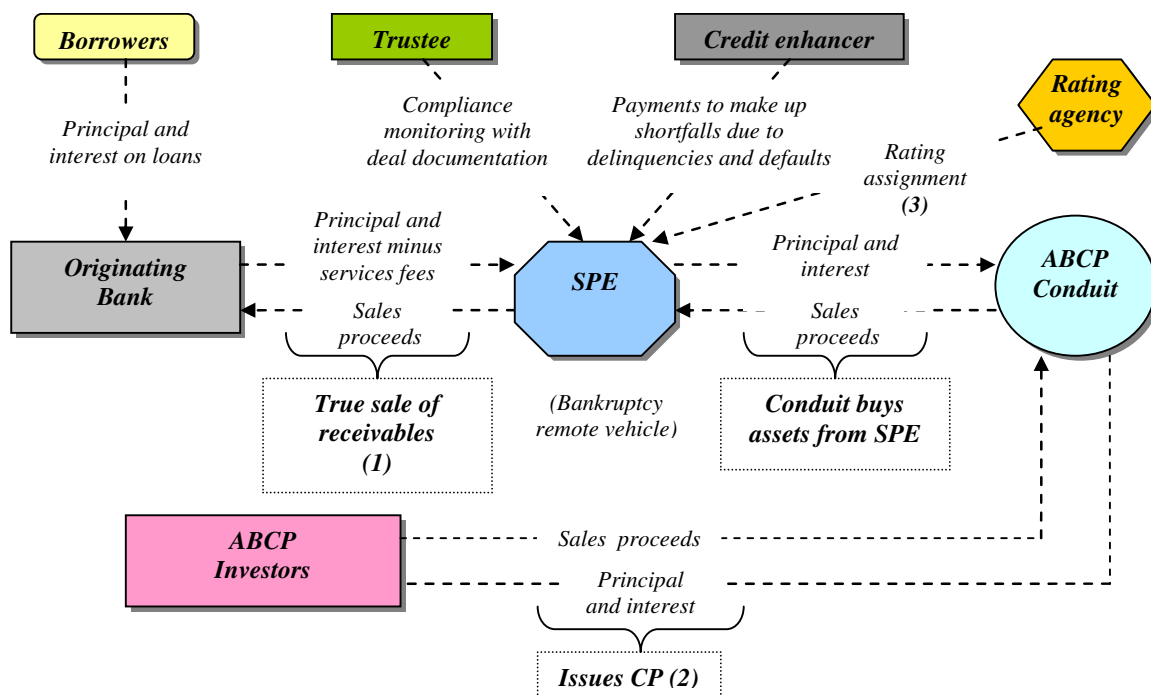
Note:

    (1) The asset is transferred from the originator bank to the SPV;

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[50] Securitisation allows for the transformation of formerly illiquid assets into portfolios of assets that can be sold widely. The risks of the associated assets can therefore be sold to economic agents that have additional capacity to bear them. Through re-securitisation, i.e., CDOs of ABSs, already securitised debts are pooled and re-tranched. Banks, for example, need to retain costly economic capital as a buffer against their risky lending activities. Selling off some of this risk via securitisation allows them to hold less costly capital and to reinvest freed up resources into the economy. Moreover, the prices of asset-backed or mortgage-backed securities transmit extra information to the market. Some securitisation may, however, be motivated by regulatory or tax arbitrage, which could entail efficiency losses.

(2) The vehicle issues bonds and sells them to the end investors in order to create liquidity. The sums gathered by the SPV are used then to pay the charges incorporated in the bonds and to cover the costs of securitization. It must be noticed that the receivable transferred are pledged as collateral for the payment of the bonds issued.

(3) Except for the junior tranche, which is normally unrated.

A key condition for such a business model to work is that liquidity is permanently made available to each market participant involved in the process.

In principle, this business model is attractive for banks since it eases constraint on growth providing them with a new source of financing in order to expand lending. Through this '*slicing and tranching*' process, originators increasingly fund themselves with often short-term securities issues rather than with traditional and stable sources of funding, such as retail deposits, which declined in importance over time. In this manner, banks can reduce their capital requirements and are able to mitigate their funding liquidity risks, although they rise funds at higher interest rates.

To quote Draghi (2008), the Bank of Italy's Governor, '*Today a bank is an institution that provides both liquidity and complex funding, not an intermediary defined in terms of specific liabilities and assets. Balance-sheet assets - in particular bank credit - are no longer an accurate gauge of the importance of banks in the economy*'.

In addition, many banks saw opportunities to generate new sources of revenue and fee income by developing and deepening their activities in international capital markets.

From the standpoint of the economy as a whole, the OTD business model could be perceived as having many advantages, because:

- with the OTD model, banks can sell part of the risk in their loan portfolio and enhance the liquidity of their assets. The OTD model allowed banks to transform their illiquid assets into marketable securities, providing an additional source of funding to expand lending. The ability to maintain a given level of credit supply with a lower volume of capital (or a higher leverage ratio) enables the banking sector to reduce the costs of financing for borrowers.

- modern financial intermediation has undoubtedly promoted economic efficiency and made capital available to productive sectors that would have otherwise not had access to any increasing the liquidity of credit markets, lowering credit risk premia, and offering investors a greater flexibility in terms of an improved menu and supply of assets and hedging opportunities as a whole.

- in addition, through the securitisation process, banks have now the possibility to offload credit risk from their balance sheet and transfer it to other investors. At least, in principle, with this new business model, the role of banks as the ultimate holders of credit assets has become less important: credit risk is no longer concentrated on banks' books, but it is potentially dispersed among a myriad of investors with different propensities for risk and different investment objectives and horizons. In this way, this securitised model seems to provide an effective mechanism to mitigate credit risk and to transfer it to other financial investors, to allocate it in the financial system in an efficiently manner and to reduce the role of banks in liquidity transformation.[51]

Nevertheless, the recent events demonstrated that some features underlying the application of the OTD model can encourage the adoption of business practices which tend to underestimate the actual risk that banks have to face. Since summer 2007 the world's financial markets have been convulsed by a crisis of increasing magnitude and multiple dimensions. The roots of current highly disturbed financial market conditions can be recognize in the specific weaknesses of financial markets current structure, in the enormous diffusion of securitisation process and structured products and in the main drawbacks of the OTD model. In order to deepen the processes which led up to the mentioned crisis, four main elements of weakness are identified. In some way, they depend on the adoption of

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[51] This variety should reduce the likelihood of large swings of asset prices caused by unidirectional trading strategies, making the financial system more stable (Visco, 2007).

OTD models and seem to affect the 2007 crisis. These variables are (a) the efficacy of credit risk transfer, (b) the credit risk monitoring and the role of agency problems, (c) the role of rating agencies and (d) the valuation of complex and structured product.

a. Efficacy of Credit Risk Transfer (CRT) Techniques

Lessons from the recent crisis show that removing assets from balance sheets does not imply that banks are no longer exposed to the risks associated with them. Other significant risks (i.e. reputational risk, warehousing risk, pipeline risk, etc.) continue to threat the activity of banks. Even if major risks have been transferred to external entities (Asset Back Commercial Paper conduits and SIVs, among others) that have taken on high levels of credit risk exposure and have performed maturity transformation by financing long-term assets with short-term liabilities, these entities are far less well equipped than banks to cope with the credit deterioration and a liquidity squeeze in stressed times, which has exacerbated investor uncertainty. In fact, such vehicles do not have capital requirements to fulfil, are not supervised by authorities and, furthermore, do not have an adequate commitment in monitoring the credit positions (graph 13).

Furthermore, under Basel II, unlike Basel I, banks must set aside capital to support liquidity commitments to such vehicles, but such commitments are treated as senior exposures, with lower capital requirement for shorter maturities. As obvious, this creates regulatory arbitrage incentives to use such vehicles.

The fragility of off-balance sheet structures and vehicles which underpinned securitisation has produced a gap between the legal commitments taken by the banks through liquidity support and credit enhancements, and the 'true' level of implicit support they felt obliged to take in order to protect their reputation as a 'constructive obligations' [52]. As a consequence, in times of stress, originators – that usually retain exposure to the first defaults on the loans they sell - will record profits (and therefore equity capital) reduction and bank balance sheets will expand considerably, lowering the amount of excess capital available to back new lending, as conduits call on their credit lines.

Lacking sufficient information, an unfavourable event might trigger losses in many dimensions. This could lead to a liquidity squeeze in money markets: banks could not be willing to lend to one another even at short maturity, generating a market failure in interbank market.

It is therefore essential to enhance the transparency of credit risk transfer mechanisms to better understand their effectiveness.

Graph 13: Risk management techniques in ABS

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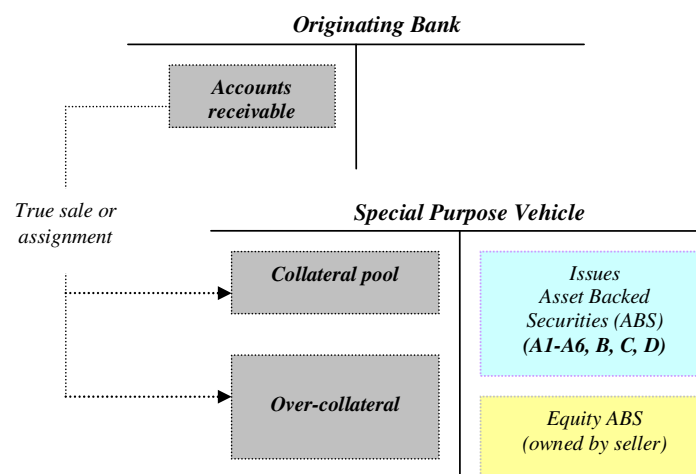
[52] This problem of non contractual support is not restricted to securitization structures. The party that obtains credit risk protection can always compensate protection sellers for unforeseen losses if it feels that claiming the greatest amount could lead to a severe damage in its reputation.

b. Credit Risk Monitoring and the Role of Agency Problems

Second, in the new securitisation model, asset originators, who are at the point of contact with borrowers, but who are expecting to pool and offload individual loans, have less incentive to assure the initial credit quality of the individual borrower and to operate as delegated monitors of their borrowers, since the originator expects to transfer credit risk to other investors [53]. At the following step, the buyers of the loans that intend to repackage them into complex credit instruments have little incentive to analyse the quality of the acquired assets for the reason that they are mainly guided by credit ratings [54]. As a result, both banks and special purpose vehicles do not have the adequate incentives to carry on painstaking credit risk analysis and, therefore, at aggregate level, credits may be allocated to suboptimal businesses.

c. The Role of Rating Agencies

Even if rating agencies were fully transparent about their methodology, there has been a misunderstanding between investors and rating agencies as to the scope and the true meaning of ratings for structured and CRT products. These players are once again at the forefront of the debate because of the intrinsic conflict of interest resulting from the fact that they are paid by issuers for providing a service to investors. The recent market developments highlighted not only technical and incentive problems of rating agencies, but also an overdependence on ratings and other limitation in investors' risk management. Most buyers of structured product were not fully aware that evaluation did not include liquidity risk, despite this being one of the greatest risks to which holders of structured products are exposed [55]. For corporate debt, it should exist a reasonably steady and consistent relationship between the rating (in term of the mean expected loss or default probability) and other types of risk (i.e., the variance of losses or defaults or vulnerability to a cyclical downturn). But the pooling and *tranching process* that is used to create CRT securities breaks this relationship and can create securities with a low expected loss but a high variance of loss or high vulnerability to the business cycle. Therefore, investors do not realize that ratings for structured products were intrinsically more volatile than simple plain vanilla securities [56].

d. Valuation

In the event of increased funding pressures, a number of banks had planned to use securitisation techniques more intensively to liquefy illiquid assets, such as mortgages, into cash. The steady shift in banks' assets from loans to not very liquid [57], by nature, structured products has magnified the sensitivity of bank balance sheets to valuation techniques. However, innovation - that propelled to the new business model - creates by itself an uncertainty on asset valuation, that is quite challenging. As a matter of fact, the steady increase in the complexity and opacity of securitised instruments has led to a lack of transparency about the risks (i.e. model risk and liquidity risk) in these products, in particular

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[53] This type of moral hazard problem is even stronger when loans are originated by non-regulated entities. On the role of banks as delegated to monitor see Diamond (1984).

[54] The obvious consequence is that, whereas in the traditional "buy-to-hold" model banks have an incentive to avoid the deterioration of quality of the mortgage, in order to prevent default, in the OTD model their interest in monitoring the borrower is greatly weakened.

[55] Market participants failed to recognise sufficiently that the high yields offered by such products were in part compensation for higher liquidity and market risk.

[56] Structured product ratings, such as sub-prime ABS, differ from corporate debt ratings in a number of different dimensions. Structured product ratings:
- refer to the performance of a static pool instead of a dynamic corporation;
- rely heavily on quantitative models while corporate debt ratings rely heavily on analyst judgement;
- rely heavily on a forecast of economic conditions.

      Finally, while a structured product rating for a particular rating grade should have similar expected loss to corporate credit rating of the same grade, the volatility of loss can be quite different across asset class (Aschraft and Schuermann, 2007).

[57] These products are structured to suit precisely the characteristics and the risk profile needed by their buyer. For this reason, they could not be sold quickly on to other investors who may not have the same preferences or needs.

with respect to the quality and the potential correlations of the underlying assets and potential the drying-up of liquidity, especially in periods of stress and extreme market volatility[58]. To better understand this issue, it is critical to explain the construction of many CRT products.

The structuring of CRT products is based on assumptions about the degree of diversification of the exposures in the underlying portfolio whose defaults correlations is a key input to design, price and manage credit structured products. The statistical concept of correlation refers to the average co-movement of the two asset prices for a well-defined period. However, the largest losses are registered in case of worst co-movement of the underlying exposures. This is more than ever true for the senior part of the CRT capital structure, which only experiences a loss when the negative performances on the underlying portfolio are very large (Graph 14).

The difference between average and worst-case correlation can be tricky to incorporate into models and not easy for market participants to understand [59]. This difficulty or inability to assess the exact value of assets for some structured products obliged financial institutions worldwide to recalibrate their valuation models and this represents a major cause of the propagation of liquidity crises [60]. Lack of information and delay in pricing disclosure amplified the crisis in 2007, undermining market confidence and exacerbating uncertainty. So far, since the ability to price an asset depends on valuation, fair value must be based on a market price and, consequently, the ability to price an assets depends on adequate liquidity in the market. As a result, if financial product are perceived opaque, market liquidity could dry up.

Graph 14: The CRT Capital Structure
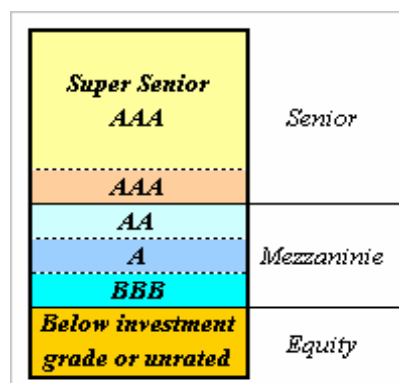
Source: The Joint Forum (2008)

7. Supervisory Approaches to Liquidity Risk

Although several countries share an almost common concept of liquidity, liquidity risk and liquidity risk management, with several descriptions and different degree of detail, the patchwork of liquidity regimes or approach is multi-coloured as to objectives and methodologies. Besides supervisory authorities which set quantitative requirements in order to face liquidity risk – largely based on stock-based approaches or maturity ladder - there are other supervisors that rely on qualitative models, or seem to prefer hybrid approaches.

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[58] Banks may lack an understanding of the behaviour of complex stochastic cash flows generated by these products.

[59] To better identify and manage correlation risk, it is indispensable to identify "stressed correlations" to recognize different parts of the portfolio that may experience higher-than-expected defaults in a stressed environment. However, for some CRT products (e.g. ABS CDOs), the correlation parameters in the rating agencies' models are not derived from any empirical data, due to the short data history available on the default history of these products.

[60] Unlike traditional bonds, these products are not generally traded in secondary markets, so no public information on their value is available.

Thus, this paragraph illustrates the most significant reasons why regulators introduced a specific set of rules for liquidity risk, analyses the several approaches to liquidity supervision and describes some practices adopted in Europe so far.

7.1. The Rationale for Liquidity Supervision

First of all, the rationale for liquidity supervision is strictly related to the function of banks in traditional financial intermediation combined with the presence of several market failures. Commercial banks play a pivotal role in the economy. They facilitate payments and the smooth transfer of goods and services, as well as they match savers - who may lack detailed knowledge of borrowers and who (generally) want to be able to withdraw their money at short notice - with borrowers who often wish to repay their loans over a longer term horizon, according to returns of their investment projects.

This 'maturity transformation' performed by banks is essentially addressed to allow capital to be invested in a productive way in order to support economic growth. As a by-product of such maturity transformation, banks are inherently exposed to liquidity risk – here considered as the risk that a bank is unable to meet its commitments should depositors attempt to withdraw their funds ahead of the bank's capacity to repay them.

The role of banking supervision is to ensure the safety and soundness of individual banking institutions. Bank failures can be happened because in the presence of asymmetric information, co-ordination failures among banks, strategic behaviour of banks to benefit from other bank's difficulty, and so on. These failures have significant social costs, for deposit holders as well as for taxpayers if the government or central bank is obliged to intervene to support a distressed institution. Therefore, these cost of banking crises were by and large perceived to be so high that they had to be avoided at all costs.

Supervisory authorities are interested in preventing banks' illiquidity for several reasons. First, once a bank is perceived to be illiquid by the other banks in the same market - in absence of a supervisory authority and without implicit or explicit commitments for maintaining the liquidity conditions in financial system – it would be very likely that the other participants in the interbank market would close the credit lines for the bank in lack of liquidity or would take back their loans. It is obvious that the role of supervisory authorities, having explicit goals in terms of liquidity of the system and of the single financial intermediaries, makes the other interbank market participants more confident on the fact that their interbank loans will be repaid.

A the same time, the necessity of liquidity controls on banking industry is often motivated by the fact that depositors do not have the same information set their bank has on the riskiness and liquidity of the investments done by the bank itself. Therefore, depositors are not able to monitor over time whether their banks are liquid and, consequently, whether they are in the position to withdrawn their deposits on demand or at the time due, according the contracts.

Furthermore, supervisory authorities are interested in preventing liquidity risk not only in order to protect depositors, which are structurally the weak contracting parties compared to the banks, but also for the systemic implication that from the illiquidity of a single bank may arise. In fact, given that banks are strictly interlinked through the payment system, the temporary illiquidity of a market participant would surely create problems to all the other banks which have credits from the illiquid banks and cannot be paid. In this eventuality, also the depositor of healthy banks could feel their deposits at risk, and, as a consequence, they could withdraw their deposits. However, such eventuality would create liquidity and stability problems also to the healthy and liquid banks, given that modern banks keep only about 0.5% of their assets in form of cash, and therefore are not able to face sudden depositors' withdrawn. The fact that depositors would not be able to discriminate between liquid and illiquid banks at a certain stage could originate a generalised lack of confidence in the banking industry, which is defined as 'deposit run'. This eventuality - which seemed to represent a remote hypothesis for modern economies, but partially occurred during 2007 crisis in United Kingdom – is strenuously contrasted by supervisory authorities because it could initiate the riskiest systemic risk.

Graph 15: The relationship between the level of Regulation and the amount of liquidity held
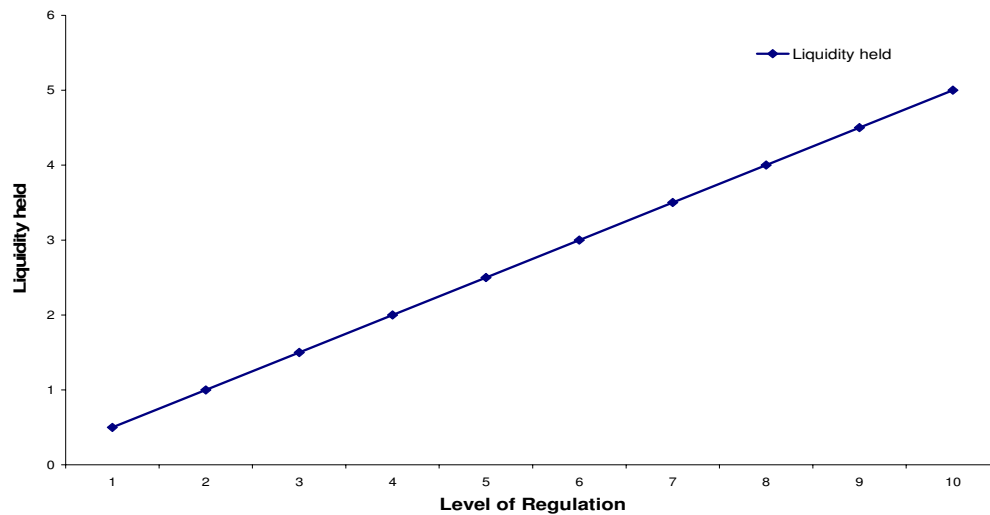
As remarked by Goodhart (2008), *'liquidity and solvency are the heavenly twins of banking, frequently indistinguishable. An illiquid bank can rapidly become insolvent, and an insolvent bank illiquid'*. Bank managers or shareholders have small incentive to take account of these externalities when choosing how to manage their liquidity risk. This may justify a role for regulators in assuring that banks select adequate levels of insurance to protect against these systemic consequences (Graph 15).

In this way, liquidity regulation is part of the toolkit that authorities have to protect against systemic crises; the main ambition of liquidity supervision and regulation is to minimize the frequency and severity of banks' liquidity drains, in order to lower their potential impact on the whole economy.

Of course, regulators are not the only 'risk mitigants' that can have influence on the banks' liquidity management. Other factors, such as the role of rating agencies and market discipline or the presence of depositor protection scheme will also have an influence, although it is unclear whether they can promote or enhance the ability to affect whether banks take account of the systemic consequences of their actions.

7.2. Diversity of Approaches to Liquidity Supervision

During the Spring 2007, the European Commission (EC) issued a 'Call for Advice' asking the Commission of European Banking Supervisors (CEBS) to provide technical advice on liquidity risk management [61]. The Call for Advice (CfA) is split in two parts:
- an updated survey of the regulatory regimes across the European Economic Area (EEA);
- an in-depth analysis of the variables that may significantly affect liquidity risk management, such as the interaction of funding liquidity risk and market liquidity risk, the use of internal methodologies by sophisticated firms and by credit rating agencies as well as the impact of payment and settlements systems design and relevant increased interdependencies.

The CEBS has given mandate to the Groupe de Contact (GdC) to conduct the task set out in the CfA. The Task Force on Liquidity Risk Management (LiqTF), set up by GdC, launched a questionnaire to all CEBS members in order to obtain an up-to-date description of their current liquidity regimes as well as recent or planned changes. According to the results of these questionnaires, supervisory regimes have been introduced at the national level for varying periods from 1979 to 2007. In a large number of European countries, such frameworks underwent some material changes and amendments or constantly slightly updated, since they were approved. This process involved extensive consultation

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[61] The Terms of Reference of the Call for Advice are available at http://www.c-ebs.org/Advice/documents/CfAonLiquidityRiskManagement20070315.pdf.

with industry and research on best practice, to ensure that credit institutions operate to the highest standards of liquidity management.

a). Objectives[62]

Nowadays there is a broad convergence on the significance of liquidity supervision and on the importance of liquidity risk mitigation. Supervisory objectives for liquidity policies mainly fall into two several interrelated categories:

- to safeguard the safety and soundness of each country's financial system, ensuring market confidence and consumer protection;
- the viability of firms' funding liquidity. Liquidity regimes must guarantee an adequate liquidity risk management (and liquidity at disposal) which enables financial institutions to meet their payment obligations promptly when they fall due at any time at reasonable cost.

The answers to the quoted questionnaire given by European countries also emphasize a combination of other most prominent objectives of the liquidity regimes (LR) at a micro-supervisory level, such as:

- survival to a fixed horizon in the event of severe funding crisis;
- limiting excessive risk taking and adherence to best practices. Across different jurisdictions, there is much diversity in how these sound practices are translated into rules and guidelines;
- minimize systemic risk and adherence to best practices;
- others (table 17 and graph 16).

Table 17: Objectives of liquidity regimes

Explicit objectives	Adherence to sound or best practices	To ensure that an adequate risk management process is in place (sound/best practices)
	Viability of firms' funding liquidity	To ensure that a banks' maturity mismatch is manageable (i.e. to meet payment obligations at all times at a reasonable cost) To ensure that a bank survives to a fixed time horizon To ensure that a bank has a minimum level of liquidity
	Survival to a fixed horizon	Survival to a fixed horizon in terms of quantitative requirements: • Sufficient liquidity buffers; • Sufficient highly liquid assets to cover unexpected withdrawal of deposits or short term liabilities,
Underlying aims	Combinations of aims: • To countermeasure against possible market failure • Limiting excessive risk taking and adherence to best practices; • Minimize systemic risk and adherence to best practices; • supervisory assessment of the risks and management practices of the institution; • protection of the interests of investors and depositors; • promotion of the development and stability of the financial and capital markets; • transparency and accountability of liquidity risk management; • methods for its identification and indicators of liquidity crisis for banks • etc.	

Source: CEBS (2008).

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[62] The following sub-paragraphs are largely based on CEBS (2008) data.

Graph 16: Results of the survey on the main categories of the EEA liquidity regime's objectives
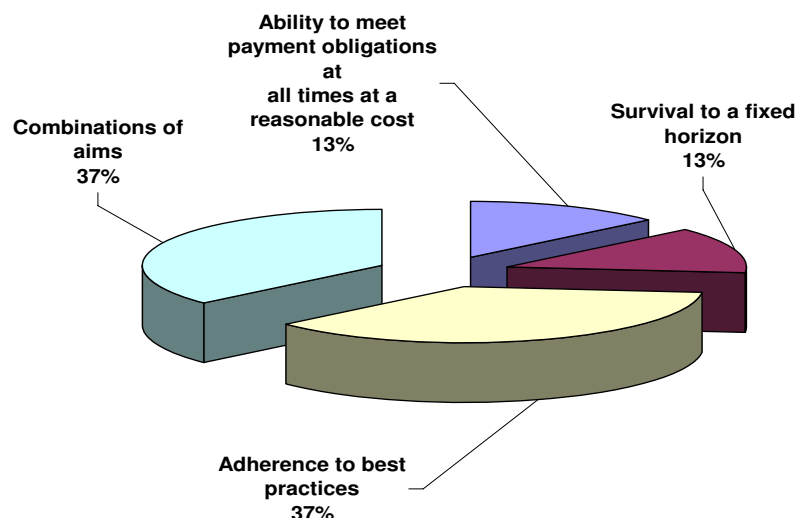
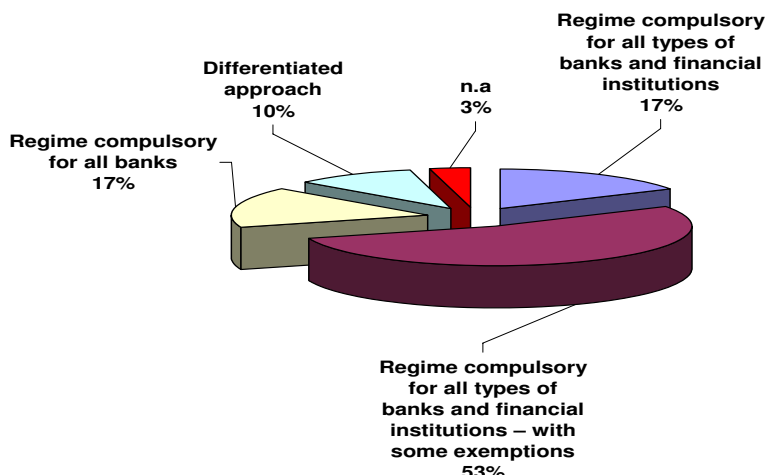**Source:** Committee of European Banking Supervisors (2008).

b). Level of Application

European banks are subject to the regulatory guidelines as indicated in Directive 2006/48/EC of 14 June 2006, which requires banks to adopt appropriate measures to develop a sound internal process for liquidity risk management. By EU Law, home supervisors are generally responsible for the liquidity supervision of a broader range of types of banking institutions operating in their country [63].

On the other hand, the organisation of supervision of cross-border banks between EEA-supervisors is regulated by EU Law. The specifics of the bilateral or multilateral cooperation and coordination are often formally laid down in a Memorandum of understanding (MoU). This holds for all supervisory home-host cooperation, whether the supervisors involved are EEA- or non-EEA-supervisors. MoU's are non-legally binding instruments. They do not override supervisors' respective responsibilities, nor do they restrict their capacity for independent decision making. They lay down supervisors' tasks and define conditions under which supervisors may send, receive and exchange information.

In the EEA context, the national LRs' objectives don't differ between types of domestic institutions (banks, branches of foreign banks, and so on) or respect to the level of application, although effective methodologies for supervision may differ in some cases (Graph 18).

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[63] Sometimes broker dealers and securities firms are included.

Graph 18: Application level of liquidity regime

Source: Committee of European Banking Supervisors (2008).

Even if some countries apply the same supervisory requirements to all supervised institutions independently of their size and category, in other jurisdictions, different rules are implemented for different types of banks. For example, in some countries the supervisory framework embodies a more sophisticated approach for certain banks (where more flexibility is granted to the institution to use internal modelling methods), while a more prescriptive approach is principally designed for smaller banks [64].

Some countries apply their liquidity regime principally on a bank solo basis, while others apply their regime principally on a group consolidated basis. Some countries even apply their regime on both solo and group consolidated bases [65]. Across jurisdictions, there is much diversity in how these sound practices translate into rules and guidelines. In addition, there is a diversity of approach to liquidity supervision within some countries. Countries which have been surveyed by the CEBS indicate that the intensity of supervision tends to increase for the larger and more systemically important firms, in proportion to the assumed increase in risk (i.e. a proportional approach).

c). Liquidity Policies

Although all countries require banks to have liquidity policies in place, there is a difference in the way such policies can be provided. Almost all regimes expect banks to take reasonable steps to maintain appropriate systems for the management of liquidity risk and to document liquidity policies in order to set out the internal strategy for managing liquidity risk [66].

Although all countries require banks to have liquidity policies in place, there is a difference in the way such policies can be provided. Some regulatory regimes do not set explicit requirements or guidance on topics to be covered. The majority, however, identifies specific area that should be documented and asks liquidity policies be regularly reviewed, (annually or more frequently as necessary) to reflect changing circumstances and to ensure that it remains appropriate and prudent.

There is a variety in issues that need to be covered in the written liquidity policies across national regimes. Firms' liquidity policies are expected to set out the internal processes in place to measure, monitor and control liquidity risk. Generally, the liquidity regimes call for a combination of several elements to be included in their policies such as the contingency arrangements or plans, the need for adequate information systems; required processes to assess future cash flows and net funding

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[64] The bank size is, in most regimes, not a factor to justify different objectives, although methodologies differ in some regimes (e.g. Germany). The exception is the United Kingdom (see sub-paragraph 7.3.).

[65] Consolidation depends on specific issues like the degree of participation, the implementation of a group wide approach, the differences between supervised entities (e.g. banks and broker dealers), and so on.

[66] Those of Supervisory Authorities that do not officially require a formal written policy, do expect a policy informally.

requirements; the importance of specific approaches for the management of foreign currency flows; stress tests; the setting of internal limits; the need for independent review of internal policies; and the need to communicate the policy through the institution.

d). Contingency Funding Plans

The importance of contingency funding plans (CFPs) is emphasised by all jurisdictions. CFPs provide bank management well-organised action plans for avoiding, minimizing or managing potential funding threats in a stressful environment (Matz, 2006). They should set out management responsibilities and procedures to be followed once the contingency plan has been activated, and they should identify potential sources of liquidity to cover shortfalls that may arise in stressed conditions.

As shown in the Basle Committee on Banking Supervision's survey, detailed and pre-established contingency funding plans (CFP) are universally required, although the formality of the requirement shows a discrepancy. Similar to overall liquidity policies, there do not appear to be fundamental differences in national expectations. Rather, diversity can be seen in some features of the requirements, or in other details such as how early warning triggers and cash flow/scenario analysis are required to be integrated into the CFP and to what extent central bank facilities can be used.

The wide industry acceptance of CFP, at least among larger banking groups, makes it less likely that there are wide disparities in the sophistication of contingency planning among different entities of a multinational banking group despite regulatory differences.

e). Stress Tests

Monitoring stress scenarios is the practical end-result of a measurement process that facilitates a firm prepare improbable, though not impossible, extreme market or bank specific events [67].

In all surveyed countries stress-testing and scenario analysis of liquidity are generally handled in a similar manner. Often, EEA supervisory authorities require banks to conduct liquidity stress testing or scenario analysis in order to have banks prepared for possible funding difficulties in a crisis situation. On the contrary, some countries (e.g. Italy) expect banks to conduct stress testing of their liquidity positions.

Generally speaking, supervisors require firms to undertake scenario testing at the same level of consolidation as their overall approach to liquidity supervision.

In some countries, the supervisor sets broad guidance as to the type of shocks that should be assessed, while in others the choice is left to the individual firm. In both cases, the behaviour of future cash flows is left to the individual firm to estimate.

There are a variety of methods used by banks to estimate the behaviour of future cash flows. At one level, the estimation may simply involve the judgement of experienced practitioners. Other institutions may use historical data or statistical modelling techniques. Supervisors have different approaches to assess and/or approve these assumptions [68].

During the recent turmoil, some supervisors asked banks to undertake additional stress tests and provide explicit guidance on how the results should be used. For example, some regimes expect the outputs of the test to feed into contingency plans or the setting of limits.

In addition to these individual institution requirements, some supervisors organise macro tests, applying pre-defined scenarios for a selection of financial (bank, insurers, pension funds) groups. These are conducted with the aim of assessing potential second-round effects and market-wide responses.

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[67] Stress tests aim to identify potential weaknesses or vulnerabilities in a firm's liquidity position, enabling changes to be put in place to counter those weaknesses (BCBS, 2008).
[68] Some require firms to provide detailed justification of their assumptions. Some benchmark across the industry. After the evaluation process, corrections may be made, and if weaknesses are determined, the supervisor may take immediate action.

f). Supervisory Model Validation
As to the internal models, their importance in liquidity risk supervision diverge across different jurisdictions and takes into account banks' internal methodologies in several ways. Only in a few cases we observe a complete reliance on internal models to replace standard quantitative requirements (e.g. Germany), to substitute standard reporting requirements (e.g. Belgium), to deliver behavioural estimates for maturity mismatches used in certain standardised quantitative requirements; as a complement to standard quantitative or reporting requirements (especially for more sophisticated firms). In some member countries the use of quantitative models to meet regulatory requirements is not permitted at all or not stated explicitly in the liquidity regime. Finally, all regimes consider stressed as well as normal liquidity conditions.

g). Reporting Requirements
All EEA countries have instated specific liquidity reporting requirements for credit institutions with the exception of some countries (i.e. Italy) where credit institutions' regular prudential reporting schemes already include information on maturity ladders and of liquid assets that enables the prudential monitoring of banks' liquidity position.

Information is collected for a variety of reasons. Some data allow supervisors to identify the liquidity risks that banks are exposed to and to monitor the level of those risks. Other data items allow supervisors to monitor the potential sources of liquidity that banks have available to them. Together, these data allow supervisors to determine whether liquidity pressure is building at the institution and whether banks are complying with regulatory requirements.

The data collected by national authorities differ greatly regarding the nature, frequency (from daily to bi-annual), form (e.g. customised form, official reporting sheet or data collection) and substance of their reporting requirements under normal conditions. The lack of a shared reporting framework:
- potentially makes it difficult for supervisors to interpret and assess liquidity reports that comply with the reporting requirement of another county and
- can create possible technical expenses to produce the required figures/reports in smaller entities

Some jurisdictions collect raw data (e.g. a balance sheet or cash flow breakdown) while others collect pre-defined metrics and ratios. The lack of a shared reporting framework makes it difficult for supervisors to interpret and assess liquidity reports that comply with the reporting requirement of another county.

h). Setting of Limits
Some regimes require banks to set internal limits or targets. These may comprise target holdings of liquid assets, limits on maturity mismatches or restrictions on the reliance on a particular funding source. These quantitative limits can help to constrain the amount of liquidity risk that a bank takes, can help to ensure that banks are adequately prepared for stressed conditions or can serve as early warning indicators of stress or vulnerability.

Several regimes prescribe explicit limits or target ratios as part of the regulatory requirements. Where targets are set for different purposes, their structures understandably vary considerably. However, ratios set for similar purposes also differ across jurisdictions in the detail of application, particularly in the choice of behavioural assumptions.

Standardised limits are relatively inflexible and hence are not so easily adapted to changing financial markets, compared to other tools such as stress tests (e.g. some do not incorporate off-balance sheet risks). In recent years several regimes have moved away from setting standardised limits and several EEA members have reported plans to update such limits in the light of market developments.

i). Public Disclosure

In most countries, public disclosure of information on firms' liquidity positions are limited to those that are required by accounting rules and other corporate governance requirements, rather than by specific regulatory requirements. Generally, accounting rules require firms to disclose a maturity analysis for financial liabilities and a description of how liquidity is managed. There are a few cases where public disclosure arises explicitly from regulatory data or where institutions are required to disclose key regulatory metrics in their annual accounts. Basel II, and in particular Pillar 3 (market discipline), should serve to increase public disclosure of liquidity positions. Recent events highlighted the importance of consolidation rules, as disclosure requirements generally are more exacting for on balance sheet instruments than for exposures associated with off-balance sheet vehicles.

7.3. A Brief Description of some Supervisory Liquidity Approaches in Europe

The brief description of liquidity regimes shows us an heterogeneous landscape. This circumstance can in theory create an administrative burden, a need of national regulation expertise and reporting requirement for financial firms that operates in countries with significant differences and finally a constraint on bank liquidity with latent trapped liquidity pools and associated opportunity costs.

Despite the standardisation of regulation in Europe is nowadays a fact in several banking business, liquidity risk prescription continue to be largely diversified on national basis [69].

a). The United Kingdom

In the United Kingdom there are three set of quantitative requirements for banks, denominated *Sterling Stock Regime, Mismatch Regime* and *Building Society Regime*. The Sterling Stock Regime aims to guarantee that, first, in the event of a severe funding crisis, an institution is able to survive until the next weekend, without destabilising asset markets or requiring extraordinary central bank funding. Second, it helps ensure that banks are able to withstand a sudden short-duration extreme liquidity 'shock'. This approach is based on stock approach and mainly applied to major retail deposit takers (about 20 big size banks with a potential systemic significance [70]) on consolidated basis. The consolidated entities are those who have wholesale inflows and outflows and which take retail deposits. They are required to hold eligible collateral for open market operations with the Bank of England to cover their five-day wholesale net outflow and a specific percentage of retail deposits withdrawable over the same period [71]. These assets are the only eligible allowed for the purposes of promptly covering the above-mentioned liabilities. The principle underlying this approach is that the bank should have a sufficient stock of liquid assets to be able to meet sterling outflows over five working days in a crisis (i.e. survive to the next weekend). It assumes all wholesale funding that matures within the next five days is not renewed but looks at the net position within 5 days. Each balance-sheet item is set in the maturity ladder according to its earliest contractual maturity, unless behavioural adjustments. Banks on the Sterling Stock regime also have to comply with a limit on their wholesale sterling net outflow and a required absolute level of sterling stock (the floor), which are set by the FSA. The floor is usually set at 50% of its wholesale outflow limit.

$$SSLR = \frac{LiqAss}{\left(NetOut_{5\_days} - CD + 5\% \cdot \mathrm{Re}tDep_{5\_days}\right)} \geq 100\%$$

where *SSLR* is the Sterling Stock liquidity ratio, *LiqAss* is the stock of sterling liquid assets, $NetOut_{5\_days}$ are the wholesale sterling net outflows over next 5 working days, *CD* are the allowable

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[69] For a quick overview on some supervisory liquidity approaches in Europe see Tarantola (2008) and Panetta and Porretta (2008).

[70] These institutions deal directly with the central bank in open market operations on a routine basis, participate in the high value payment system, and in normal times themselves distribute liquidity more widely across the banking system).

[71] See Financial Services Authority (2007).

certificates of deposits and $\mathrm{Re}\,tDep_{5\_days}$ are the sterling retail deposits over next 5 working days. There are no haircuts applied in the Sterling Stock regime.

On the other hand, the *Mismatch Regime* is applicable to all other banks on an individual basis. Through a maturity ladder scheme, this approach aims to ensure that individual institutions have enough assets to meet their day to day liquidity requirements. Mismatch requirements are set for all other banks, but with the possibility of modifying them for individual firms. Assets eligible for inclusion at sight are those which pass the marketable asset test. Factors consider are the depth of the market, likelihood of forced sale, the proportion of a debt issue that a bank holds and exchange rate risk [72]. As to the banking system, all regimes try to mitigate market frictions – such as asymmetric information, coordination failure, strategic behaviour of banks to benefit from other banks' difficulties, and so on - that may prevent a solvent bank from attracting sufficient funds.

Last, the *Building Society Regime* is a specific approach adopted by building society, which impose such financial institution to maintain a constant ratio between some categories of liquid assets on one hand and short-term liabilities over next 8 working days on the other hand.

b). Germany

In Germany there are two possible approaches on liquidity risk that banks must fulfil. The simplest one is said Standardised Approach and is based on a common set of rules. Furthermore, since January 2007 banking institutions – under specific conditions – may at their discretion adopt the 'liberalisation clause' of the section 10 of the Liquidity Regulation, using their own internal liquidity models for supervisory purposes instead of the Standardised Approach. These institutions are required to regularly review the adequacy of the calculation and the monitoring of liquidity risk for the validation of their model. In order to assess the adequacy of these internal models the Federal Financial Supervisory Authority (BaFin) uses quantitative analysis and application of a *'use test'* principle. In addition, the liberalisation clause allows BaFin to determine the utilisation requirements at the level of the entire group of institutions or financial holding group [73]. The adequacy of liquidity models is evaluated according to an audit process performed jointly by BaFin and Deutsche Bundesbank. While the BaFin and the Bundesbank designed only general principles for the banks implementing internal models, those which continue to adopt the Standardised Approach must fulfil a liquidity ratio, which is largely based on maturity mismatching [74], but it takes also into consideration those assets that are considered highly liquid, regardless the maturity [75]. The German liquidity regime specifies how the assets are to be valued for purposes of meeting the quantitative requirements. Marketable assets are segregated into two categories by their degree of relative liquidity: Tier 1 assets include components which are cash or may be immediately convertible into cash. Tier 2 assets comprise other assets according to their residual maturity which can not immediately be converted into cash. Listed securities are normally to be slotted in the first time band with their market values; if an institution does not dispose of any market values on a daily basis, the listed securities may be slotted with their book values by applying differential discount factors. The use of an institution's own procedures for the purposes of liquidity monitoring under the new liquidity regulation requires approval by the BaFin.

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[72] Further minimum criteria that has to be met are prices are regularly quoted for the asset, the asset is regularly traded, the asset may be readily sold, including by repo, either on an exchange, or in a deep and liquid market for payment in cash, and settlement is according to a prescribed timetable, rather than a negotiated timetable.

[73] For example, a credit institution which is a subsidiary of a banking group or a financial holding group can be exempted from the liquidity regulation if the group it belongs to applies an internal liquidity risk measurement and management that has been jointly assessed by BaFin and Deutsche Bundesbank and finally approved by BaFin.

[74] The time horizon covered is one year

[75] In addition, three "observation ratios" are calculated for the time-bands over the next calendar month, such that if the liquid assets existing in one time band exceed the callable payment, the positive mismatch has to be considered as additional liquid assets in the following time band.

c). France

French liquidity regime is made up of two complementary set of rules.

The first ones are merely quantitative and are aimed at ensuring a satisfactory match between assets and liabilities in a way that bank could survive to a fixed time horizon. The liquidity ratio covers a time horizon of one month. Credit institutions have also to compute observation ratios at the end of each quarter and provide the Banking Commission with them together with the liquidity ratio. There is no rule based on the idea that the bank must hold specific assets. The numerator of the ratio comprises the treasury balance (when it represents a lender position) and assets with not more than one month to run: lending, treasury bills, bonds and other fixed income securities deemed as liquid, shares and similar securities quoted on an official French market or on an organised foreign market offering the same assurance of liquidity. The specific haircuts applied to certain type of items of the liquidity ratio are set on certain assumptions of behaviour.

The second ones, which are qualitative, are designed to achieve, to some extent, best practices. All types of French credit institutions (e.g. banks, mutual or cooperative banks, limited liability real property banks, finance companies, municipal credit banks) are subject to the liquidity requirements [76] with no matter on which type of business they carry out. Nevertheless, liquidity quantitative requirements are valid on an individual basis whereas qualitative requirements impose credit institutions to have a liquidity risk measurement and monitoring system in place on a consolidated level.

d). Italy

As to the Italian financial system, mandatory quantitative requirements are not in place [77]. The Bank of Italy set up a liquidity framework substantially derived from the findings of an international working group [78]. The main purpose of Italian liquidity framework is to make sure that financial institutions are able to manage their expected liquidity needs in a prudential manner under 'on going concern basis' and they should be able to absorb unexpected liquidity exogenous and endogenous shocks through stress testing of their liquidity position.

The framework is based on a maturity mismatch scheme under normal operating conditions and in the presence of shocks; that is, whether financial inflows and outflows match or there are probable misalignments, in the short time horizon covered (three months). The maturity ladder is built according to a probability-based approach in which on balance-sheet and some off-balance sheet items (e.g. customer deposits, undrawn credit facilities, etc.) are weighted to take into account their variability over time. Weightings attached to these items stem from time-series analysis of prudential reporting data which are periodically revised and vary according to banks' exposure to possible liquidity shortages.

The aim of the assessment is not to check whether the bank is always liquid, which is an impracticable task given that the bank's operations involve intra-day adjustments and revisions of the liquidity position. Nor does the analysis assess the profitability of treasury operations, since profitable cash management does not in itself require that flows of liquidity be matched.

The intensity of application – even if the approach is applied to all supervised domestic institutions both on a solo and on a consolidated basis (only insurance companies are excluded), independently of their size, activity, business, or structure both on a solo and consolidated basis - tends to increase with the financial institution's complexity and size (i.e. a proportional approach).

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[76] Instead, investment firms are subject to liquidity quantitative requirements as defined by the national regulation relating to internal control in credit institutions.

[77] Italian liquidity framework does not require banks to comply with regulatory standards or limits regarding the management of liquidity risk. The abolished supervisory rules were in place until very recently. They dealt with maturities transformation of balance sheet items and required banks to comply with mandatory asset-liabilities relationships

[78] See Basel Committee on Banking Supervision (1992) and (2000).

Liquidity position is examined half yearly for each bank through off-site controls. The exam produces an automatic liquidity rating, which takes into account both normal and stress scenario results[79]. Nevertheless, liquidity can be examined at shorter intervals and is generally assessed on the occasion of on-site inspections.

Qualitative and organisational aspects are, assessed within the more general framework of on-going supervision on internal controls systems regulations.

8.   Liquidity Risk of Financial Firms: Some Ideas for an Effective Risk Management

The recent market turmoil started in the US sub-prime market highlighted several fallacies in the contemporary financial system. First of all, it has been demonstrated how the current risk management practices - largely based on models which make use of publicly available prices and ratings – as well as supervisory tools are not completely appropriate to face the risk of extreme evens, such as the sub-prime market crisis and the consequent liquidity dry up. The reasons of the summer-2007 crisis are surely based on an excessive euphoria on credit market which lead to a systematic underestimation of risk premia; however, the misinterpretation of the actual credit risk largely depended on the unbounded confidence of banks and financial firms to be continuously able to securitise and re-securitise any kind of credit and to transfer the risk on the market. The overarching principle that governs the treatment of (both traditional and synthetic) securitisation structure in Basel II framework is that the relief in capital that can be achieved by an originator through an effective securitisation transaction should, in principle, be proportional to the effective risk transfer to third parties. The amount of regulatory capital required for each position in the securitisation structure is determined, either by recourse to a look-up table based on external ratings or through the use of a particular supervisory formula. Thus, the difference between the required capital for the underlying pool of non-securitised exposures and the securitised originator's positions is taken as the measure of risk transfer. Furthermore, the capital that banks are required to keep in order to support liquidity commitments towards special purpose vehicles is treated as senior exposure, with lower capital requirements for short maturities.

Clearly, the crucial question is how confident banks and supervisors can be that the minimum capital requirement that follows from the application of Basel II is adequate in all securitisation programme. As a matter of fact, there is a patchwork of possible underlying exposures and the 'loss waterfalls' can be set in many different ways. However, the adoption of originate-to-distribute business models implied that, in case of generalised crises, the markets of structured securities issued by special purpose vehicles tend to become illiquid and banks are called to provide margins and, in extreme circumstances, they may be forced to buyback the assets sold, which in such context had to be devalued. In the Basel II framework, these type of risks are generally tackled under the 'Pillar II umbrella', where capital add-ons can be charged while the valuation of the treatment efficacy of all special features of securitisation transactions belongs to the Supervisory Review Process (SRP).

In the light of above, the proposal of the Basel Committee on Banking Supervision – which is currently debated – to strengthen the capital treatment for banks' liquidity facilities to off-balance sheet vehicles, in order to reduce the existing regulatory arbitrage incentives, can be considered as a first step in the right direction. Also the idea to raise Basel II capital requirements for certain complex structured credit products and strengthen the prudential framework for off-balance sheet activities seems a necessary measure in order to link actual risk and capital.

Second, the OTD model demonstrate to foster moral hazard because banks, which are supposed to exist also for their capability to perform a 'delegated monitoring', have no longer incentives to screen and monitor their customers, since the credit risk is transferred on the market. The risk of a lack

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[79] Rating should not be considered as indexes of the liquidity position of a bank in a precise moment, rather they express the potential riskiness and the ability to cope with difficulties in liquidity management, in the light of the asset-liability maturity mismatching and the overall technical condition of the bank.

of incentives for banks for adequately assessing the creditworthiness of customers, which is implicit in OTD model, seems that has been underestimate by the supervisory authorities of those countries where large banks massively adopt such strategic behaviour.

Third, the special purpose vehicles, which play a pivotal role in the OTD model, are not adequately capitalised and supervised and, as a consequence, can represent a threat for the overall financial system, given that the securities they issue are widespread distributed in the portfolios of numerous operators. Again, global regulators and supervisory authorities should make a effort in order to introduce stricter rules addressed to reduce the chance for financial groups to avoid the consolidation of special purpose entities and, more generally, to report in the banks' balance-sheet the actual risk that may arise by positions apparently transferred on the market. At the same time, it is important to bear in mind that the recourse to interbank funding, strictly related to business models oriented to increase the lending activity without a direct relationship with the capability to raise funds among depositors, makes the intermediation process more expensive and volatile. In periods like the second half of 2007, when the risk premium on unsecured interbank deposits compared to repo operations touched 120 basis points in US and 80 basis points in the euro area, the capability to finance the lending process through more stable retail deposits represents a key element that significantly contributed to the stability of financial system. The fact that an high percentage of liabilities of some banks adopting OTD models is represented by interbank funds should be more and more considered in the future both by risk managers and regulators.

Fourth, as far as banks' liquidity management, it is evident that, nowadays there is not a metric that seems to be completely adequate to prevent liquidity crises. Unlike for other risks, where capital requirements are the rule, an higher capitalisation indubitably improve the capability of a bank to raise funds on the interbank market, but is arguable whether it is an effective solution for facing liquidity risk. The direction in which regulators and risk managers are moving after the 2007 crisis is to promote liquidity models not standardised, which take into consideration the complexity and the nature of the bank. However, the key elements that, according to practitioners and regulators, cannot be missing are clear governance rules aimed at defining a liquidity risk strategy, tasted methodologies for assessing liquidity position over time based on prudential hypotheses including extreme events and contingency liquidity plans to be adopted in case of crisis [80]. Such models, furthermore, had to be coherent with the intragroup cash flows management, as well as with the optimisation of debt issuance policy and ALM goals. In this framework, a closer dialogue between supervisory authority and banking industry, aimed at a better knowledge of the methodologies adopted by banks for contrasting liquidity risk and a validation of such models by the supervisors – as recently experimented in Germany - can represent a first interesting experience to evaluate.

In designing the models for liquidity management there are several features that, according to the evolution of global markets and the complexity of financial groups have to be adequately considered.

Unless the high degree of standardisation experimented for other kind of risks, national regulators continue to adopt differentiated approaches for supervising liquidity risk, alternatively based on qualitative and quantitative tools, or established on a mix of methodologies. The 2007 events, given their global dimension, demonstrated the necessity of a closer coordination among supervisory authorities and central banks in order to maintain smooth liquidity conditions. Considering that the risk factors which can affect the liquidity position of banks are the same in the vast majority of markets, it is clear the need for regulators to do an effort toward an higher standardisation of regulatory approaches on liquidity; such attempt is considered essential also in order to avoid that, as a result of the recent crisis, every single regulatory authority could implement heterogeneous liquidity requirement that significantly alter the cross-border competitive environment. However, regulatory authority and multinational financial institutions did not agree on the best liquidity approach so far.

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[80] For an updated overview on European supervisory authorities' standpoint see Committee of European Banking Supervisors (2008).

Last, it has been often affirmed that in 2007 crisis credit rating agencies were an important trigger. In fact, such agencies, paid by banks, assigned high ratings to sub-prime-related securities between 2004 and 2007, thus contributing to the significant growth of sub-prime lending. The standard conflict of interest of credit rating agencies may be more severe for structured finance ratings, because these agencies usually discuss with the issuers the rating implication of particular structures. Thus, it seems necessary that regulatory authorities will manage to strengthen internal governance of credit rating agencies, in order to limit conflict of interests and enhance the rating methodology process for structured credit products. In the meanwhile, authorities should rethink the large use of external rating in regulatory and supervisory frameworks, because authorities in last years played a role in investors' and banks' reliance on rating, implicitly discouraging some investors from paying closer attention to what the rating actually mean.

One lessons from the recent turmoil is that significant improvements in some quantitative and qualitative disclosure requirements – that are included in the Pillar III of the Basel II Framework but which are not yet enforced – concerning firm's exposures to structured credit products and securitized assets will improve and should not only make a contribution in the future stressed market situations, but also facilitate communication to market participants about risk profiles of banks and other firms. Only in this way, Pillar III will help market participants better evaluate banks' risk profiles and will enhance discussions between bankers and market participants about risk management practices. Confidence in the risk management practices of individual firms can be valuable in maintaining reliance in the markets in which the firms operate.

Last, in a context of turbulence and liquidity dry up on interbank markets, in which banks aimed at lending only to counterparties considered solid – coherently with the *name lending approach* - the Italian interbank platform e-MID, that is screen-based, transparent and efficient, represented a valid solution for improving the liquidity distribution among banks which, otherwise, would be less available to negotiate with other financial institutions considered not surely solvent.

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