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Liquidity risk management

*Assessing and planning for adverse events,
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Introduction

Recent turmoil in global finance markets has yielded new evidence for the importance of liquidity risk management as a sound business practice. A phenomenon that started as a narrowly focused fear regarding increased delinquency in the subprime segment of real estate mortgage lending has since widened its effects to result in a systemic liquidity shortage worldwide.

A look at recent spreads between rates for three-month interbank deposits and three-month interest rate swaps reveals that this dangerous pattern still persists. Until the beginning of August 2007 the spreads between the two curves were stable at a relatively narrow level. Since then, however, while derivatives such as interest rate swaps have closely followed the official rates of central banks, spreads in relation to interbank deposit rates have suddenly increased, broadening to a high of 144 bp (UK, September 2007). (See Appendix I) Since the difference between deposit rates (which imply liquidity lending) and derivative rates (which do not) reflects the cost of liquidity, these findings clearly indicate that the effects of the liquidity shortage are still highly visible.¹ Despite a subsequent temporary reduction, the spread failed to return to normal levels and by the end of 2007 had begun climbing again. This development has been especially difficult for floating-rate borrowers whose interest burdens are indexed to soaring interbank rates.

In response to these trends, five central banks (the United States Federal Reserve Bank, the European Central Bank, the Bank of England, the Bank of Canada and the Swiss National Bank) announced unprecedented, coordinated measures to reduce pressures on short-term funding markets. The Fed will auction USD 40 billion in two equal tranches on December 17th and 20th, 2007. It will also hold two more auctions in January 2008, with amounts still to be defined. The Fed also agreed on swaps with the European Central Bank (USD 20 billion) and the Swiss National Bank (USD 4 billion), which will allow these Central Banks to inject USD-denominated liquidity into their local markets, timed to match the dates and durations of Fed operations.



The Bank of England and the Bank of Canada also announced their willingness to participate in the coordinated action, although with local currencies. In addition, the involved central banks took measures to broaden the range of beneficiaries of this liquidity by expanding the list of instruments eligible as collateral. The Fed also substantially increased the span of the institutions eligible for this financing scheme by opening the auctions to all those eligible to borrow under the Discount Window program (i.e., not only to the few that are Fed counterparties in open market operations).

Many analysts remain concerned about the weaknesses that persist in the global picture and warn that a new crisis could be pending. Banks with scarce liquidity, as well as most non-banking financial institutions, have been forced by the cash shortage to borrow on a shorter-term basis than normal, with rates remaining far higher than central bank targets. The increase in interest rate burden acts as a de-facto restriction in monetary markets, while extensive borrowing on sub-optimal short maturities increases systemic risk, impeding optimal management of maturity mismatches. Warning signs come from falling real estate prices and the number of additional transactions, especially in the United States. Assessing the size of potential losses in the mortgage loan sector, the Organization for Economic Cooperation and Development stated that a total of USD 300 billion could be a plausible amount (reported by *The New York Times* on November 23, 2007).

This paper takes a close look at the factors involved in the recent crisis and the patterns that resulted in widespread liquidity problems. It also points to specific vulnerabilities faced by financial institutions currently, and highlights best practices for liquidity risk management. Findings include a strong recommendation that financial institutions apply quantitative analysis to liquidity risk to the same extent as they currently do for market and credit risk, and increase analytical accuracy by incorporating dynamic stochastic methodologies. Since the potential impact of liquidity risk is typically much more severe than the consequences of market risk – in some circumstances threatening a company's very survival – the use of up-to-date quantitative instruments such as these can be viewed as a necessary development in today's unsteady economic environment.

Unraveling the liquidity crisis

Connections between market liquidity risk and funding liquidity risk were highly instrumental in causing a relatively confined, credit-related problem in the subprime real estate market to result in a system-wide credit crunch. As the Financial Stability Forum puts it, "The turmoil has brought to light interactions between credit, market liquidity and funding liquidity risks that many regulated financial institutions did not anticipate." (*Preliminary Report to the G7 Finance Ministers and Central Bank Governors*, 15 October 2007).

Factors that connected the two and triggered the liquidity shortfall included: massive securitization; overuse of collateralized securities; loss of confidence in ratings (i.e., in analysts' ability to evaluate the actual risk inherent in asset-backed paper); failure to recognize the full scope of risk involved in maturity mismatch; and inadequate diversification.

Types of liquidity risk

The Basel Committee on Banking Supervision defines 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." It also defines market liquidity risk as "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." (*The Joint Forum, Basel Committee on Banking Supervision, The Management of Liquidity Risk in Financial Groups*, May 2006)

These are qualitatively different types of risks that must be approached using different methodologies. In particular, although capital can be effective in addressing market liquidity risk, it is not necessarily a strategically effective method for approaching funding liquidity risk. Since capital might not be maintained in a liquid form, even financial institutions with sound capital ratios could in principle be exposed to funding liquidity strains under unexpected stress conditions. The correct way to build up an effective protection against funding liquidity risk, therefore, is to clearly define an adequate amount of cash, promptly marketable assets and other instruments for quick fund-raising (e.g., irrevocable stand-by facilities), and then maintain that level, adapting it as needed in relation to business developments.

Contributing practices

Many common financial practices have turned out to be extremely problematic in a market climate where unpredictable downturns in a single sector can affect the entire global economy.

Massive securitization

In the period prior to the liquidity crisis, lenders frequently used the practice of securitization to offset their assets as a whole, packaging them into portfolios that delivered certain immediate benefits. Granularity and diversification led to a substantial improvement in asset quality, which was certified through independent evaluation by rating agencies. High-rated asset-backed securities were created to finance the purchase of such portfolios, which were viewed as liquid and suitable for trading in global markets. Many loan originators routinely used securitizations as an effective way to fund asset portfolios at a relatively low cost, while maintaining a low risk profile by transferring credit risk to other players in the market.

At the same time, the development of credit derivatives acted as a multiplier to increase the variety and complexity of asset-backed products, making them suitable for an increasing range of users – including retail holders of investment funds – with very different risk appetites. This led to reduced transparency about the actual risk inherent in investment products and to a loss of control over who in the market was actually bearing the final credit risk.

When the credit bubble burst, a number of issues emerged. First, securitizations can be structured in many different ways, and not all of them are equally effective in genuinely transferring credit risk to bond holders. In fact, many loan originators retain the so-called “junior” tranches of securitizations, i.e., the ones that have the worst rating and entail most risk. These bonds absorb the first wave of possible insolvencies from the securitized portfolio. (“Senior”, or higher-rated, tranches are only affected if delinquency exceeds a certain amount; they are therefore more protected from risk and achieve better credit ratings.) This was problematic, since a wide range of contractual clauses can allow recourse to the loan originator, at least to a certain extent, in case of delinquency in the securitized portfolio.

Second, many originators did not fully dispose of the asset-backed paper, and used it as collateral for short-term facilities or commercial paper programs, leveraging the net interest margin. This way, however, they retained the credit risk inherent to that paper. (They also exposed themselves to a maturity mismatch, discussed below.)

Finally, even originators that were most effective in transferring credit risk to other parties did not actually offset the entire risk from their asset portfolios. When global confidence in the creditworthiness of the mortgage industry plummeted, the willingness of investors to absorb new asset-backed paper evaporated, and so did the ability of these firms to fund new activity. No matter how effectively they had used securitizations to transfer credit risk, they had in fact retained liquidity and reputational risk.

Dependence on collateralized securities

Another common practice was to use asset-backed securities as collateral for cash facilities. By retaining some parts of securities backed by an internal asset portfolio, loan originators could obtain finance from banks at lower interest rates, benefiting from the low credit risk associated with the bonds, as certified by good ratings. Originators could also use the securities as collateral for commercial paper programs to further improve interest margins, leveraging the spread between the yield of the bonds and the cost of short-term finance. High ratings, large issue amounts and active trading on the global market helped maintain low credit spreads for bonds, and also generated a widespread confidence that such paper was only to a small extent exposed to credit or liquidity-related price volatility.

Unfortunately, these assumptions turned out to be mistaken. This practice exposed the originators to a twofold risk: first, they did not dispose of the credit risk associated with the loans backing the retained securities; second, they took on the liquidity risk from the mismatch in maturities of the commercial paper and securities to be financed. When prices plunged, there were substantial calls for new collateral, triggering funding liquidity problems. Essentially, margin calls on collateralized facilities caused a market liquidity problem (illiquidity in mortgage-related paper and subsequent price falls) to result in a funding liquidity problem (inability of firms to raise funds to match new calls for collateral).

Rating

A crucial element in all securitizations is to obtain a high credit rating for the asset-backed paper. A high rating permits the asset-backed paper to bear low interest rates and to be suitable for active trading and collateralization against cash facilities. One typical way to achieve this is to package a wide number of fragmented, uncorrelated transactions into a single portfolio and securitize them as a whole. As a result of diversification, the delinquency risk of the portfolio is substantially lower than that of the underlying transactions. Additional guarantees are often added to ensure a higher degree of protection for investors. During the pre-crisis period, the ratings of securitized portfolios were often higher than those of the originators, who were then in a position to reduce the interest rates they paid to banks by offering high-quality paper as collateral. Mortgage loans were considered particularly suitable for this sort of scheme.

Conventional assumptions evaporated, however, when hundreds of subprime-backed issues were downgraded by major rating agencies due to evidence of increasing delinquency.² Standard & Poor's announced in a press release on July 10th, 2007 that delinquency trends for many subprime mortgage-backed issues of 2005 and 2006 were larger than expected, in a way that "called into question the accuracy of some of the initial data provided to S&P regarding the loan and borrower characteristics." As a result of increasing delinquency, S&P introduced some changes in its methods for assessing the credit merit of securitizations, including "increasing review of the capabilities of lenders to minimize the potential and incidence of misrepresentation in their loan production. A lender's fraud-detection capabilities will be a key area of focus."

These events caused a general loss of confidence in ratings as trustworthy indicators of credit risk. The impression spread that the risk embedded in mortgage-backed securities could be far higher than that implied in official ratings. Such an attitude was not limited to subprime loans but expanded to mortgage-related paper in general, and thus contributed to the collective runaway from such paper witnessed in subsequent months.

Maturity mismatch issues

A fundamental role of banks in modern economies is to fill the gap between the planning horizons of borrowers and those of lenders. Borrowers typically need funding with a maturity that is longer than the time horizon on which money lenders are ready to invest their liquidity. Banks and financial institutions must therefore transform shorter-term investing by final lenders into longer-term finance to borrowers. They do so by borrowing on maturities consistent with a lenders' investing horizon, and transferring this finance to final borrowers with longer maturity. This causes them to take on the risk inherent in the mismatch in maturities of assets and liabilities.

The risk connected with maturity mismatch is the economic justification for the lower interest rates that typically apply to short-term borrowings as compared to longer term finance. In recent years, many institutions have evidently viewed this practice of leveraging the spread between maturities as a kind of arbitrage exercise, paying little attention to the underlying risk and thus helping to set the stage for crisis conditions.³

Inadequate diversification

Diversification has proven a crucial element in determining crisis levels during the recent turmoil. Well-diversified firms, although in some cases suffering substantial mortgage-related losses, did not in general experience a threat to actual survival. Diversification applies to both sides of the balance sheet:

- **Diversification of business** – Firms specializing in a particular industry or segment are more exposed to extreme risks than diversified ones, as they are unable to compensate for adverse events in their core industry with profits in other sectors of activity. This is the main reason why conglomerates tend to expand into different, uncorrelated or inversely correlated industries.
- **Diversification of funding sources** – The distinction here is between more and less volatile sources of finance. Retail deposits tend to be more stable and to remain with a bank even in crisis circumstances. Wholesale funding tends to be more volatile and to dry up more quickly. A dangerously slim retail deposit base can prove a crucial cause of liquidity shortage. In fact, this type of liquidity risk has been cited in best practice documents issued by the Basel Committee, local regulators and analysts. Regulators also insist that diversification of funding sources must be taken into account in stress analysis and contingency plans.

In times of emergency, inadequate diversification under the two sides of the balance sheet make a crisis more likely. Industry-specific problems can induce wholesale lenders to withdraw their support to firms specializing in that industry, whereas retail depositors will remain. Thus, firms that rely more heavily on volatile wholesale sources of funding are more likely to experience liquidity problems. Oddly, although the connection between diversification and liquidity risk is well known, many firms have failed to grasp how this relationship has contributed to the current liquidity shortage.

Northern Rock is a good example. This UK-based bank maintained a low level of diversification from the perspective of both assets (business segment specialization) and liabilities (retail deposit base). This weakness proved to be a key factor in triggering severe liquidity problems. In August 2007, Northern Rock nearly went bankrupt and was saved only by a bailout by the Bank of England. Ironically, as late as the end of July 2007, it had stated that calculations of capital requirements according to Basel II Pillars 1 and 2 showed an excess of capital, allowing the bank to initiate a capital repatriation program. It is obvious that when performing such calculations, the bank failed to take into account all factors that could affect its liquidity position even in the very short term. In particular, it is likely that the bank neglected the dangerous concentration that would very shortly cause the institution to suffer extreme threats to its existence.⁴ (See *Appendix II*)

In summary, extensive use of asset-backed paper as collateral for cash facilities proved to be a strong link between market liquidity and funding liquidity. The decrease in the prices of collateralized securities triggered calls for additional collateral or facility reimbursement, directly resulting in funding liquidity problems. At the same time, investors became unwilling to refinance short-term maturing liabilities of institutions specializing in mortgages, so that maturity mismatches within such firms became another cause of liquidity crises. Inadequate diversification also accelerated

problems in many companies. In addition, fears about delinquency rates in the subprime segment – made worse by a loss of confidence in ratings and the valuation of the credit risk of asset-backed paper – rapidly expanded into a sharp revision in asset allocation policies of investors globally. This led to a generalized fall in the prices of asset-related paper and in many organizations made it impossible to structure new securitizations to provide business funding.

Expectations that a “flight to quality” would favor well-managed, less risky firms proved unfounded. Even lenders with sound loan portfolios found themselves unable to refund maturing liabilities, since no investors were available to roll over CP and other short-term borrowings. Thornburg Mortgage, Inc., based in Santa Fe, New Mexico, is a remarkable example. After being forced to sell a large portion of company assets at a substantial discount, Larry Goldstone, Thornburg’s CEO, stated: “Through no action of ours and through minimal risk-taking on the part of the company, we had to incur a \$930m loss in order to be sure the company survives. We don’t have bad loans, we don’t have a bad credit portfolio. We spent 14 years building a reputation as a premier high-quality mortgage company, and in one week the market has destroyed a lot of that value and a lot of that hard work.” (See *Appendix III*)

Liquidity risk management: Best practices

A number of tools and methodologies are commonly used by financial institutions in managing liquidity risk. In view of recent events, however, some of these techniques may need to be re-evaluated and supplemented with approaches that can bring greater depth and accuracy to the risk management process. A comparative investigation into various analytical methodologies reveals that the most effective means of alleviating liquidity risk is to apply quantitative analysis within a stochastic (versus deterministic) framework – gaining the same kinds of benefits that have been seen over the years in areas such as market and credit risk.

Integrated stress scenarios

Liquidity risk has some special characteristics that differentiate it from market and credit risk. For example, liquidity risk has a low probability of occurrence, and at the same time can potentially have extreme consequences for a firm's stability.

Unexpected strains to liquidity can be firm-specific (e.g., unusual concentration of requests of utilization of committed facilities granted to customers) and can result from the shrinking of funding sources due to a loss of reputation. Pressures can also have industry or systemic characteristics, affecting firms even if they have no direct involvement in risk-taking activity. In all cases, financial institutions can be exposed to extreme risks if they fail to prepare for emergency situations.

It is vital to have a clear understanding that ordinary practices and procedures for a thorough flow of operations in normal contexts, no matter how orderly and effective, can by no means be considered sufficient to ensure that liquidity is adequate for firm's stability and survival, even in the very short term.

Firms should always maintain a comprehensive awareness of their risk profile and of the risk factors that could result in the worst potential impact. Contingency plans should be established and reviewed periodically in keeping with an evolving global risk picture.

The need to perform periodical stress tests on liquidity exposures is supported by statements from both the Basel Committee and local supervisors, emphasizing that:

- Assumptions underlying stress testing should be subject to periodical revision.
- Results of stress tests should be incorporated in the structure of internal limits.
- Stress tests must be the basis for elaborating contingency plans, in so far as they provide evidence of the extent of interventions that could become necessary to ensure stability in case of unexpected liquidity emergencies.

Emphasis on quantitative analysis

Whereas the use of sophisticated quantitative approaches – for both normal and stress conditions – are widely accepted for market and credit risk, the same is not true for liquidity risk management, despite the fact that liquidity risk can have more severe consequences. In fact, neither the Basel Committee nor local regulators in general explicitly require banks to use sophisticated quantitative methods to manage their liquidity positions. However, they specify that in managing liquidity risk banks should not rely only on simple static maturity ladders and provide a wide range of indications on additional instruments that should be ordinarily available. For example, regulators have made statements such as:

- Banks should define assumptions on the future behavior of assets and liabilities in building up their maturity ladders.
- Liquidity should be analyzed utilizing a variety of what-if scenarios.
- Liquidity exposures should be subject to periodical stress testing to assess the impact of unlikely adverse events on bank's stability.
- Banks must have in place contingency plans that allow them to promptly cope with unforeseen liquidity shortages.

The lack of standardized quantitative approaches to liquidity risk relates in part to its fundamental nature. Liquidity risk is difficult to quantify in a single number representing an accurate, comprehensive view of it. Some attempt has been made through ratios, but so far this has not become a standard approach, as can be seen by comparing the differing requirements that have been imposed by local supervisors.

Beyond the static maturity ladder

The basic instrument for liquidity risk management has typically been the static maturity ladder of cash flow projections. Even in this case, it can be shown that quantitative analysis is needed for accurate and reliable information.

In order to construct the cash flow maturity ladder, future cash inflows and outflows are distributed within time buckets according to their maturity. The durations of the time buckets typically start at one day for the shortest term and widen gradually over subsequent periods. The granularity of time buckets, especially in the shortest term, is extremely important. Liquidity problems may arise suddenly, so that a bank's ability to match all of its immediate commitments is vital for stability. Intra-day information on cash flows can also be important, especially for those banks that may experience large cash fluctuations as a result of situations such as payment or settlement services granted to other intermediaries.

Future cash flows are then analyzed both on a day-by-day balance basis and on a cumulative basis. Imbalances give an understanding of how great the bank's cash exposure is expected to be in the near future. Firms usually establish internal limits based on these figures, imposing a constraint on treasury regarding exposure to maturity mismatches. In addition, some regulators specify the kinds of limits that must be set.

The reliability of the maturity ladder is a direct function of the reliability of the figures that are input into it, but even so, implications for cash projections are by no means straightforward. A number of issues must be addressed, and in most cases depend on quantitative tools for effective assessment in a liquidity risk context.

Upgrading information systems

An effective and timely flow of information is essential for an accurate estimation of liquidity exposure. Actual cash flows can be affected by activities in different departments of a firm, or even by events that originate outside it. Examples of internally generated events include new draw-downs of credit facilities, securitizations, new trades in securities, changes in the market value of securities given as collateral for cash, and others. Examples of outside events include breakdown of the payment or settlement network, failure by counterparties to honor commitments to pay, and so forth. The firm's information system must ensure that its treasury department receives with no delay all information on any event that might

affect liquidity positions. As the Basel Committee puts it, "a strong management information system is integral to making sound decisions related to liquidity."

Coping with third-party initiated events

Some cash flows are initiated by third parties. Predictions here are difficult, since these cash flows are subject to non-contractual maturities or variant customer behavior. Examples include: demand liabilities; mortgages and other loans with prepayment options; payment commitments; repurchases of a bank's paper from captive clientele; and unutilized stand-by facilities granted to customers.

Banks require reliable estimates of the potential impact of such items. Behavioral models for demand liabilities and prepayment options are becoming more and more common for tasks such as increase of net interest income, management of interest rate exposure in the banking book, and optimization of hedging transactions. Behavioral models can also be used to draw evidence for a more accurate estimate of potential cash inflows and outflows in the near term. Other events, such as the use of margins on unutilized facilities or the need to honor payment commitments, may be estimated by historical experience. Even here, however, quantitative analysis should be considered due to its potential to increase accuracy. In general, assumptions used for the figures in the maturity model should be prudential rather than optimistic, to ensure that actual outflows are never underestimated.

Understanding the impact of collateralized securities

The price volatility of securities is heavily dependent on such factors as credit risk spread and market liquidity. Even highly rated, actively traded paper can very quickly become illiquid as a result of a change in market attitude and risk perception/appetite. Such a change in market behavior can affect not only individual names, but also industries or types of debtors, so that the prices of entire categories of bonds may suddenly plunge. If such bonds have been used as collateral, new margin calls follow. Subject to the weight of such collateralized securities on a bank's funding, the liquidity position can be affected substantially, as many banks discovered during the recent crisis.

In order to assess future cash flows, the exposure of collateralized bonds to price volatility should be estimated in a thorough, reliable manner. Quantitative tools offer the best support for accurately modeling bond price exposure. Mere estimation of future bond value, even within a probabilistic context, is probably not sufficient. Banks need to cope with the possibility that at any time prices will plunge more than envisaged under probabilistic scenarios. In fact, this is what recently happened with mortgage-backed securities. High credit ratings and active trading on the market would have suggested a high degree of safety against price volatility. Nevertheless, such factors did not prevent the paper from becoming illiquid. The market lost confidence in ratings, prices collapsed, and the growing fear that the embedded risk could be much greater than expected led a significantly large number of bond holders to sell.

Stress tests for collateralized securities

Banks that believe margin calls against securities could represent a severe risk for their liquidity position should regularly perform stress tests for the value of collateralized securities. It might also be advisable to go a step further in this prudential approach, applying the resulting haircuts to the current market value of bonds within the maturity ladder. Treasury could then be obliged to ensure the availability of cash sources great enough to cover not only the more likely cash flows, but also the stressed ones.

As shown by recent experience, market conditions can become so extreme that liquidity literally vanishes, as no one is willing to buy. Mark-to-market prices cease to have a meaning, as there is no possibility to trade. A decisive factor for this can be (and actually was for subprime paper) the spread of a “herd behavior”, whereby all players try to sell at the same time and no one is available to buy. A question arises: Should regular stress tests be based upon such extreme assumptions? And if so, would it be logical for a firm to put in place protection measures strong enough to ensure finance at any time, even in such extreme conditions?

In principle, the correct answer to both questions would be yes. In the subprime crisis, institutions that did not properly address this issue faced severe risks and consequences. However, measures protecting against such events could prove costly, and a difficult trade-off could emerge between safety and performance. These issues go beyond stress testing and relate to a firm’s core business strategies, implying fundamental decisions about industry positioning and business diversification.

Creating projections for derivatives

Derivatives are commonly subject to collateral agreements, and therefore affect cash flows depending on changes in market values. In general, however, their potential impact on actual liquidity exposure is less severe than securities because their market value is less dependent on credit spreads and product liquidity. Nevertheless, a bank should have the ability to project future cash flows from derivatives. This process entails the use of quantitative tools to model exposure to market value fluctuations that could result in new calls for collateral.

Considering liquid assets

Liquid assets are important in assessing exposure to liquidity risk in so far as they can be transformed easily into new finance by means of sale or repo transactions. Securities that are accepted by a central bank against cash should be treated as promptly available finance. In general, quoted securities qualify as liquid assets since they can be disposed of in the market to raise cash. However, prudential haircuts must be applied to market values in order to compensate for a possible decrease in price that might be experienced when going to market. In fact, some regulators, such as the UK’s Financial Services Authority (FSA), define a standard grid of haircuts to be applied when including marketable assets in the maturity ladder. Haircuts should also reflect each security’s degree of liquidity. Stress scenarios can provide further clarity, depending on the kind of securities held and the weight of the security portfolio in relation to the institution’s liquidity position.

Considerations that relate to collateralized securities also apply here, especially if the portfolio of liquid assets is significant. Assets that are marketable under normal conditions can become totally illiquid in stress contexts where no buyers can be found and there is no significant market price. In principle, stress scenarios should take these possibilities into account, recognizing differences in the probability of occurrence between different categories of paper.

Organizational best practices

A crucial requirement for effective risk management, both in normal and crisis environments, is a thorough knowledge at the senior management level of a firm's business and its associated risks. Funding liquidity problems can arise not only from easily visible sources internal to the firm, but also from events outside, unrelated to any actions or problems on the firm's part. Signs of a possible incoming liquidity crisis can be noticed even outside the conventional borders of firm's business. A sound information system and a strong intelligence capability are necessary to ensure that the firm maintains a comprehensive awareness of risks at the enterprise level.

In addition, strategies for coping with emergencies have their basis in daily operations. For instance, it is essential that a firm work hard to maintain a wide framework of business relationships in the financial arena and improve its reputation in the market. It might also be advisable to maintain a minimum level of facility utilization, to avoid the possibility that infrequent utilization will give counterparties the impression that a firm is facing liquidity issues.

The management of liquidity risk under a crisis context does entail a trade-off between risk and underperformance, which in some cases can be very hard to optimize. Considering the low probability of occurrence of funding emergencies, incurring high costs for extensive protections

could appear irrational. Nevertheless, firms that had not properly addressed this issue faced difficult times during the subprime crisis. Managing the trade-off is a key challenge for the executive team.

Liquidity risk management issues may also lead to very fundamental decisions regarding business strategies. For instance, a firm may conclude that it is exposed to unacceptable liquidity risks due to excessive concentration and may therefore take actions to increase diversification.

Optimal decisions require full awareness of risk at the senior management level, and this in turn requires that risk assessment remain independent. Risk assessment must not be biased by business considerations such as costs, compatibility with business plans, or other factors. Business considerations should be added only at a later stage as a way to achieve a comprehensive view of opportunities and threats and to be in a position to make effective business decisions with a comprehensive long-term risk-return perspective. An argument can be made that risk management might be compromised in situations where risk assessment and management are not under the direct supervision of senior management but rather report to lower level managers. A typical example is the CRO reporting to the CFO. A firm should ensure that the additional responsibilities of the CRO supervisor are not an obstacle to delivering complete, unbiased risk recommendations and estimates to senior management.

Optimizing quantitative analysis

Where institutions have already adopted quantitative analysis for assessing liquidity risk, the typical approach has tended to be a deterministic one, such as the static maturity ladders described above. In these cases, probability distributions for determining risk exposures are not utilized. Scenario analysis is based on user-defined assumptions, and resulting estimates therefore produce only a single view of the future.

The stochastic framework

A more effective alternative is the stochastic approach, which has already been proven effective for both market and credit risk management. In a stochastic framework, the future values of risk factors are calculated under a number of randomly generated scenarios, producing probability distributions. This approach can be expressed in formula, using Cash Flow at Risk (CFaR) as a measure of the maximum loss expected as deviation from the mean, with a confidence interval alpha for a defined holding period:

$$CFaR(\alpha)_t = CF(\alpha)_t - CF_t(\text{Ref})$$

Where:

- [alpha] is the confidence interval in which the cash flow at risk will not be exceeded by the maximum loss.
- CF[alpha] is the cash flow with left tail confidence interval alpha.
- CF1(Ref) is the cash flow in the reference case (typically the mean of the stochastic distribution).

From CFaR, a further risk indicator can be drawn, namely Liquidity at Risk (LaR), which can be defined as the portion of available liquidity that remains with the firm after Cash Flow at Risk has been entirely subtracted. In formula:

$$LaR(\alpha)_t = AvailableLiquidity(\alpha)_t - CFaR(\alpha)_t$$

Where: Available liquidity is defined as the amount of liquidity than can be raised with the level of risk aversion the financial institution is willing to handle. One method of calculating this is to look at the counterbalancing capabilities based on balance sheet liquidity and available unsecured funding. The balance sheet liquidity is the amount of funds that can be raised from sale or repos of liquid assets (thus the secured funding). Just as with Value at Risk (VaR), CFaR and LaR can also be split into their component risk factors to gather information about where the firm is most exposed.

The more comprehensive the scope of scenario-based analysis, the more effective the cash flow projections and risk evaluation can be. For this task, as many significant risk factors as possible should be subject to stochastic scenario generation and analysis. Risk factors can include projected future developments in market rates, customer behavior, credit spreads, or other market characteristics. Analysis of the resulting probability distributions can produce a comprehensive view of the firm's exposure to liquidity risk, improving on the limited findings that deterministic approaches alone can provide.

Limitations of deterministic stress testing

Under a deterministic approach, stress tests take the form of user-defined what-if analyses. The quality of the results obviously depends on how realistic the assumptions are. For instance, a very common procedure is to use a parallel shift scenario, whereby exposure is recalculated after applying a uniform shock to a risk factor (e.g., a one percent increase along the interest rate curve). Such parallel shifts are highly unrealistic, so that the resulting evidence is not likely to occur, and the conclusions drawn remain impractical.

Another common practice for deterministic stress testing is to draw examples from specified events in the past (e.g., September 11, the LTCM crisis or other similar crisis points) and replicate the shocks actually experienced after these events within current market curves and values. However, history never repeats itself. Each market crisis is different from all others; even crisis events that may appear similar to each other actually occur in different market contexts and have different impacts on market variables. Therefore, indications from history can be misleading.

In addition, the deterministic approach provides no information about the probability that a certain scenario will prevail. Even complex assumptions on market behavior (such as curve twists etc.) that can make scenario generation more sophisticated will probably fail to improve predictions. Therefore, it is highly unlikely that a deterministic analysis will be effective in predicting crisis events.

Incorporating stochastic methodologies

A stochastic approach to stress testing produces risk indicators based on probability distributions and has a higher predictive ability about future market developments. A typical way to perform stress tests under a stochastic approach is to examine the tails of the probability distribution curves obtained through scenario generation. The tails represent the extreme events in the random range, which occur infrequently. The left tail – namely, the worst case outcome – is where most risk exists. In-depth analysis of the left tail yields an understanding of which events and risk factors present the greatest potentially adverse impact.

However, simple observation of the tails cannot be considered sufficient as a full stress test for liquidity risk. In fact, the random scenario generation procedure always depends on parameterization and historical data, and therefore cannot take into account events that represent discontinuities in market behavior. Experience teaches that this consideration is of particular importance for liquidity risk, as events that cause extreme consequences on firms' liquidity positions frequently result from sudden market discontinuities or disruptions.

Said differently, human judgment can never be dismissed. Therefore, firms should test their liquidity exposure under user-defined stress assumptions in order to assess the impact of events that are not likely to be envisaged with standard Monte Carlo scenario generation. In a stochastic framework, this can be achieved by incorporating stochastic modelling into specific deterministic events. In this manner, scenarios are compounded by combining stochastic and shock deterministic scenarios.

It might be argued that a single deterministic event (such as increased interbank spreads) could have the largest impact, thus rendering a more complex type of analysis unimportant. However, the fact is that deterministic analysis alone illuminates only one path. Combining this view with stochastic scenarios could result in a crisis scenario which otherwise may not have been tested. A combined approach thus delivers much more information and is particularly important where non-linearity exists. Although the stochastic scenario is no longer parameterized to current market conditions in such a circumstance, this is the whole purpose of stress testing.

Less prescriptive stress testing can be achieved by stressing the stochastic scenarios directly; for example, by allowing short term correlations between risk factors to change (such as the correlation between treasury and interbank rates). An extreme test could even decouple the correlations and increase the volatilities in order to reveal the resultant impact on liquidity. The advantage of such an approach is to return tail scenarios that may not be envisioned in a purely deterministic stress test but which could cause an unforeseen liquidity situation.

Event analysis

When performing stress testing, firms should in general consider that in crisis scenarios a number of variables could behave differently than they would in normal conditions. Therefore, prudential assumptions should be considered when modeling behavior under stress caused by demand liabilities, committed facilities to customers, prepayments, or other

factors. In addition, events should include both firm-specific and industry/market related events. The actual list differs across cases and depends on each firm's business and risk structure. As a general indication, these events might include: rating downgrades; rapid drying-up of volatile wholesale funding channels; systemic impact of individual name or industry events; refusal by counterparties, for any reason, to honor committed lines or credit risk mitigation agreements; or other types of disruptive circumstances. As noted above, firms that rely to a significant extent on facilities assisted by collateralized securities or that hold large amounts of marketable securities should perform regular stress tests to assess their potential exposure to funding liquidity risk if this paper becomes illiquid or price plummets.

Dynamic analysis: Integrating business strategies

Examinations above describe the assessment of future cash flows within a firm's current situation. On the one hand, static analyses and stress testing of this type can ensure an orderly management of daily operations and safety against unlikely, severe events. On the other hand, they do not provide sufficient information to support effective management of liquidity risk over the long term. For this task, the time variable must be fully incorporated into liquidity risk analysis.

Future business assumptions

The first step in achieving a more accurate picture of exposure based on current figures under a normal (not stressed) scenario is to include planned roll-overs and reinvestments that are an integral part of ordinary operations. Products such as IBM® Algo One Asset Liability Management (ALM) Base, with its Dynamic Trading Strategy (DTS) functionality, permit users to integrate planned transactions into the liquidity picture. Large liquidity gaps are highly likely to disappear, mismatches will be reduced, and the probability distribution of mismatches will reflect a more realistic view of future exposures.

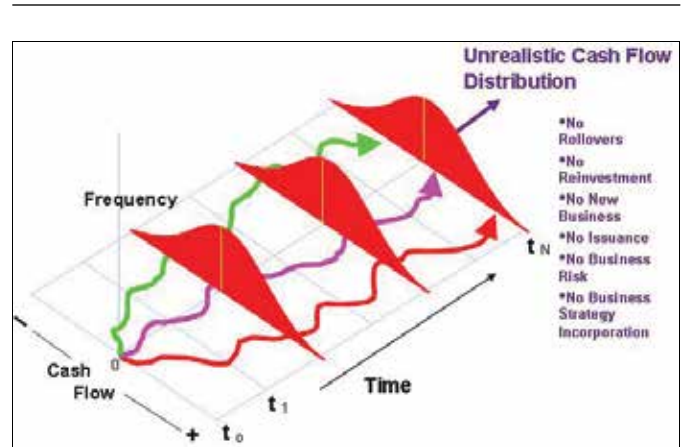


Figure 1: Stochastic distribution of cash flows without future business assumptions

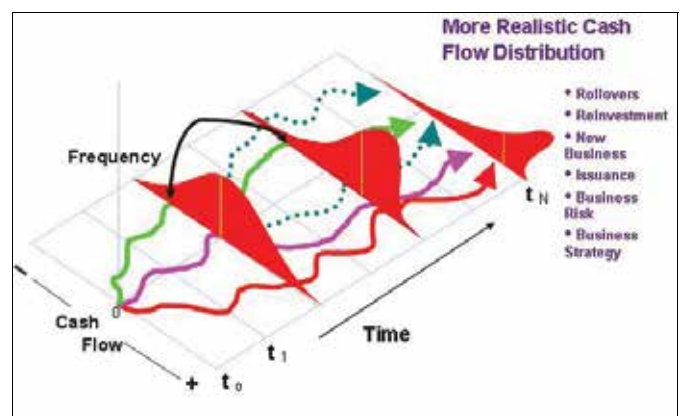


Figure 2: "Shifted" stochastic distribution after inclusion of business strategy and future business assumptions

Funding alternatives

Since a firm is a living entity, exposure to liquidity risk is subject to continuous change as a consequence not only of past operations, but also of new business. Effective management of liquidity risk must ensure that the company can raise enough finance to support the planned development of business in an orderly manner. Failure to do so could jeopardize the growth of the firm or, in the worst case, strain its financial structure and increase risk exposure. The ability to assess the impact of different funding alternatives on the balance sheet is also crucial for optimizing debt and capital and boosting value creation. Firms should have the ability to integrate business development strategies as well as inherent business constraints into their liquidity planning activities.

Figure 3 displays multiple approaches to stress testing. “No behavioral assumptions” looks at a purely static view of the balance sheet. “Forecasts and rollovers” incorporates new business and rollover assumptions. Stress scenarios “Forecast, no rollover” and “Forecast, no rollovers, committed drawdowns” reveal the impact of a run on deposits along with a drawdown on committed bank facilities executed in an attempt to counteract these threats. Although these are extreme variations, they clearly demonstrate the importance of including business strategies within the stochastic frameworks.

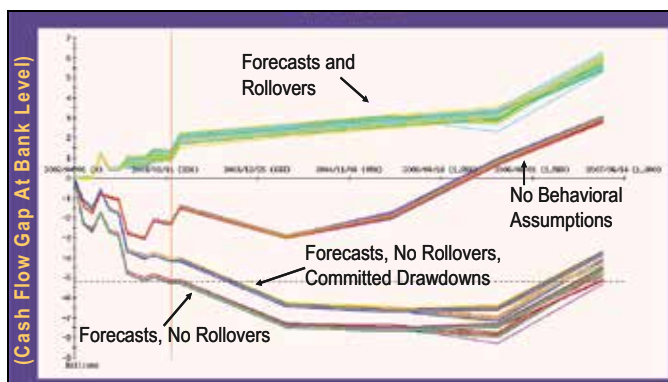


Figure 3: Stochastic scenario-based forecast changes after inclusion of business strategies.

Stress simulations

Simulation exercises can help optimize business and funding strategies. The growth of assets implies greater funding needs, and affects variables such as asset maturity and duration. New finance can be drawn from different sources, with varying impacts on the firm’s liquidity equilibrium and capital structure. Funding sources include: cash flow from ordinary business; new deposits; issue of senior or subordinated debt; share capital increases; securitizations and others. Inherent constraints to consider include internal or regulatory targets such as: limits; maturity/duration gaps; amount of (senior or subordinated) outstanding debt; amount of minimum available spare liquidity; risk indicators as Cash Flow at Risk or Liquidity at Risk, and others.

Stress simulations can produce a comprehensive view of a firm’s current exposure to liquidity risk, as well as the potential evolution of liquidity risk within the business planning horizon. They also set the stage for effective crisis management planning. In this way, a firm can assess how capable it is of maintaining stability even under unforeseen, severe adverse events, both firm-specific and systemic. Algo Asset Liability Management (ALM) can contribute here as well, providing a broad comprehensive picture of liquidity exposures over time in both normal and stress contexts.

For best results, stress simulations should be regularly repeated, periodicity mainly depending on the pace of change in a firm’s balance sheet evolution (e.g., substantial growth in assets, changes in funding strategies and so forth) or in market behavior. Contingency plans should be reviewed regularly as well. As a matter of principle, each new stress test on potential exposure is a reason to review the contingency plan and assess whether it remains consistent with newly identified potential exposure under stress conditions.

Applying stochastic scenarios

Integrating business strategies into stochastic scenarios produces a complete, probabilistic picture of the planned evolution of the balance sheet, and thus a more realistic model of balance sheet potential development. Specifically, dynamic stress scenarios within a stochastic framework yield tails that provide new information as to where liquidity risks concentrate and which risk factors will produce the most exposure. Any number of specific stress scenarios can be generated, producing a complete picture of potential risk over time. The combined technique reveals likely future evolution and risks, and increases the effectiveness of contingency planning in view of both normal and stress conditions.

The dynamic stochastic approach to balance sheet planning also supplies a comprehensive answer to the requirements set down for banks by supranational and local regulators regarding ICAAP (Internal Capital Adequacy Assessment Process). According to these regulations, banks are required to put in place a process to calculate the amount of capital that they deem necessary to support all their risks, including the ones for which no regulatory capital is envisaged under Basel II Pillar 1 (including liquidity risk). Calculations must refer not only to the current balance sheet, but also to its likely future developments, within a time horizon consistent with formal planning (budget and pluri-annual plans). Modeling the planned evolution of the balance sheet within a dynamic stochastic framework satisfies these requirements while also leading to a more efficient use of capital and an enhanced ability to develop effective contingency plans.

Given the events of 2007 liquidity risk will be the next frontier for risk management. For too long it has been the forgotten risk. Liquidity risk management is evolving from a framework of ratios and limits to one where quantitative methods are a key. There is no single equation that will provide an assessment of this risk (such as VaR) but rather a simulation framework is required which incorporates stochastic scenarios, behavioral strategies and extreme stress tests.

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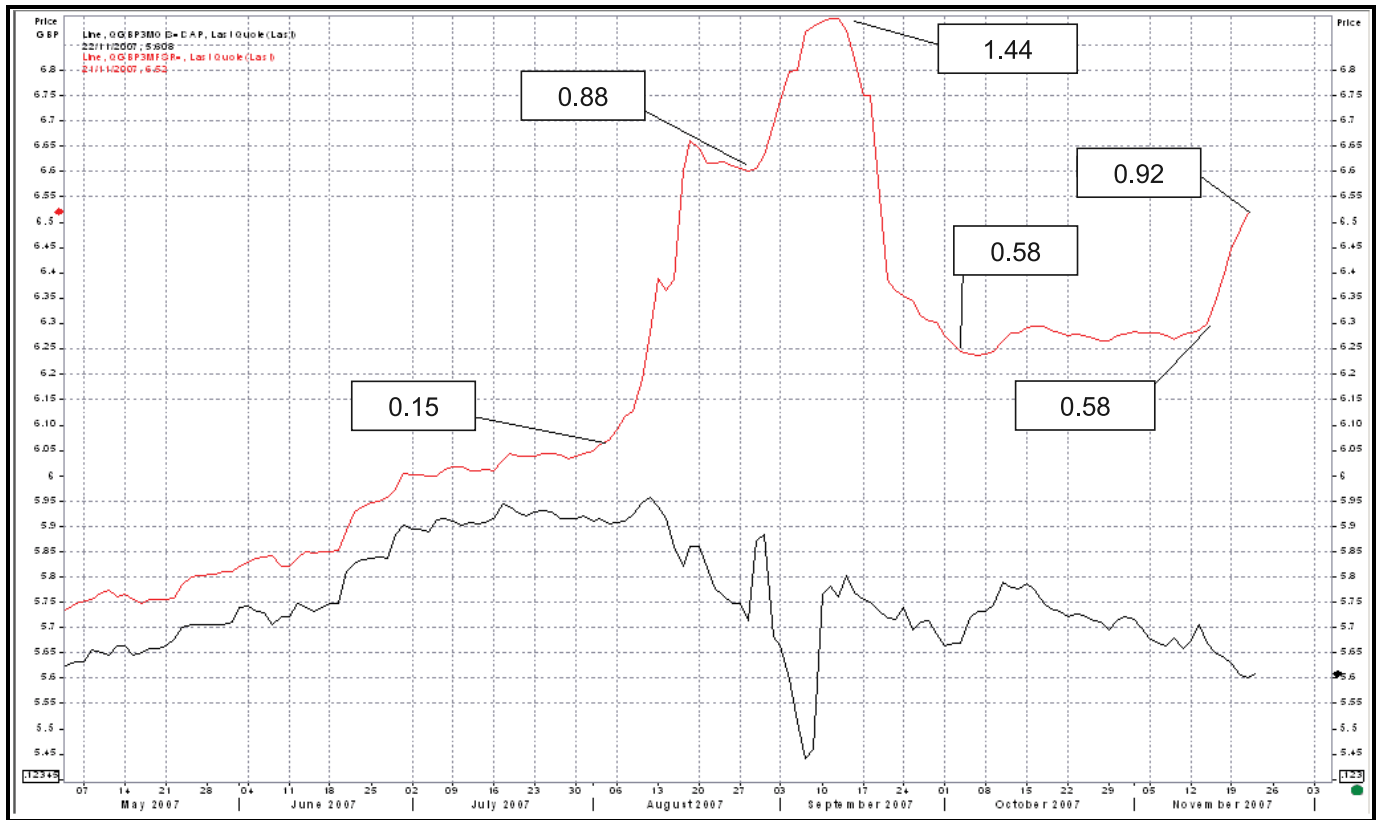
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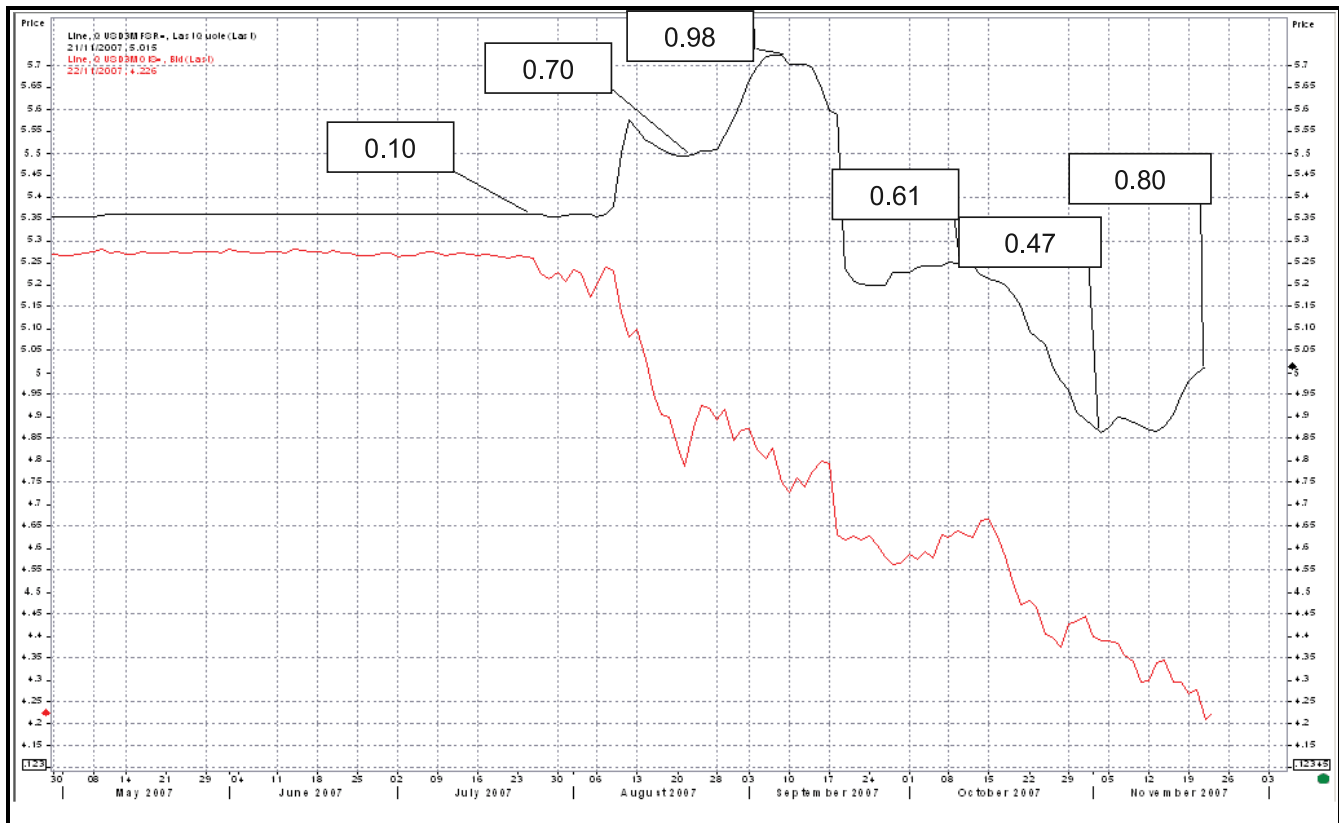
Appendix I

Interbank Spreads: comparison between three-month interbank deposit rate and three-month interest rate swap for GBP, USD and EUR



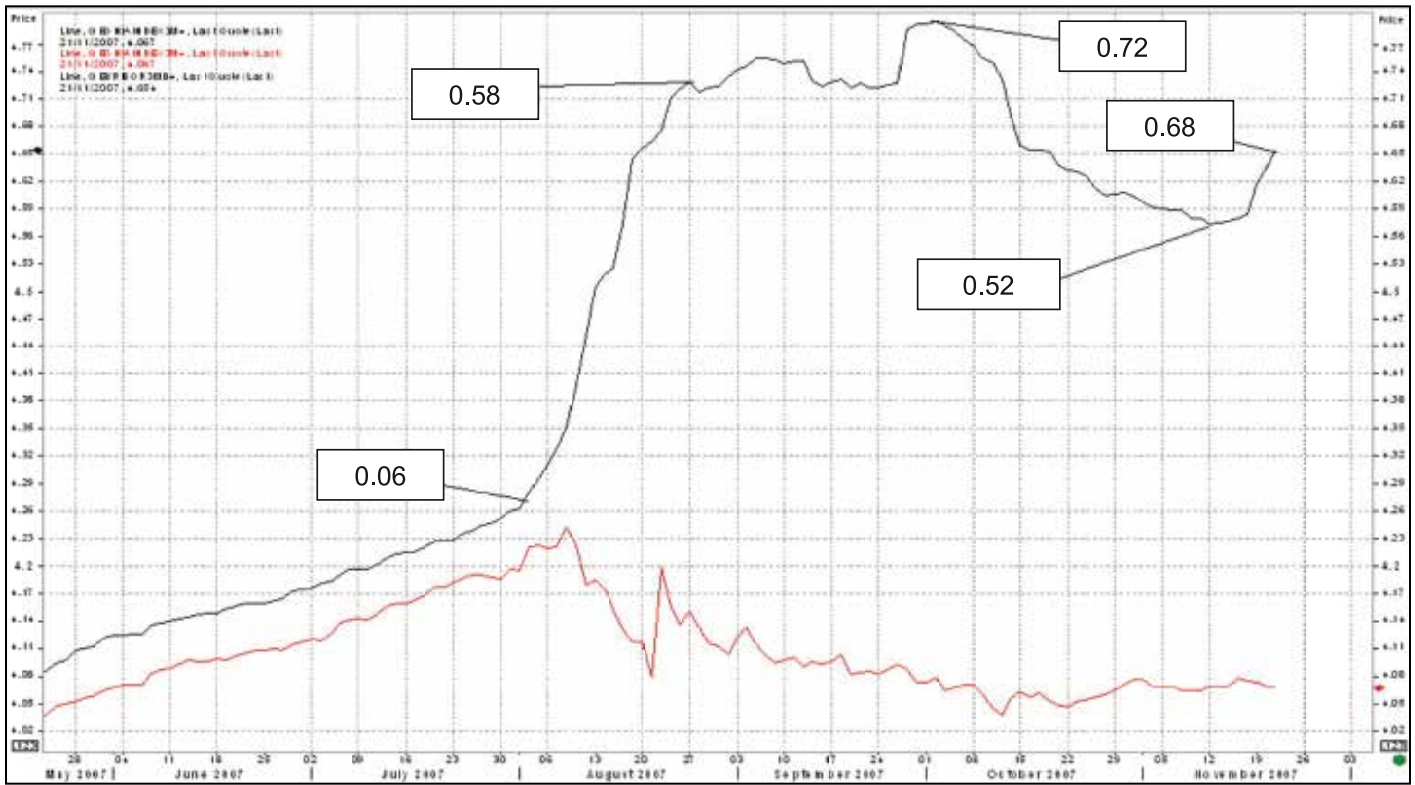
Source of data: Reuters Replicating Portfolios in IBM® Algorithmics Portfolio Construction & Risk Management for Fund Managers: Installed Edition

Figure 1: Interbank Spreads: GBP. Red line: 3-month Libor. Black line: 3-month interest rate swap (SONIA)



Source of data: Reuters

Figure 2: Interbank Spreads – USD. Red line: 3-month interest rate swap (USDOIS). Black line: 3-month Libor



Source of data: Reuters

Figure 3: Interbank Spreads – EUR. **Red line:** 3-month interest rate swap (EONIA). **Black line:** 3-month Libor

Appendix II

Northern Rock plc

Northern Rock plc was the third largest mortgage lender in the United Kingdom, with 1.4 million retail deposit accounts, 76 bank branches and 800,000 mortgage borrowers. It was the first major British financial institution to find itself in a liquidity crunch following the start of the subprime credit crisis in the summer of 2007. By mid-September, an estimated \$2 billion had been drained from the bank's accounts, share price had plummeted, and the Bank's market value – which in the spring of 2007 had been placed at £5.2 – had dropped to only £1.1 billion. Fortunately, the Bank of England stepped in to prevent disaster, and the bank remains a leading financial institution in the UK today.

Northern Bank was not considered a reckless lender. It had a good credit record with only .47 percent of its loans in arrears (about one-half the average rate for British mortgage lenders). The bank's troubles were attributed primarily to its reliance on funding from capital markets – through securitizing mortgage loans and borrowing money from the issuance of short term debt – over funding based on customer deposits. (Most banks balance their funding more equally between customer deposit accounts and capital markets.) The bank was well diversified in its capital market sources of funding; its major vulnerability was associated with the unlikely prospect of an entire shutdown of the wholesale lending markets – the exact scenario played out in 2007.

The history behind Northern Rock's pattern of risk started in 1999, when the bank launched a securitization program named Granite as a way of boosting its share of the UK mortgage market. Granite was designed to raise money by securitizing Northern Rock's loans and to provide liquidity and funding so that it could finance new mortgages. The Granite strategy involved the bundling of mortgages and the subsequent issuing of bonds. Funds flowed into Granite from what Northern Rock collected in interest payments from its mortgage customers.

Northern Rock's reliance on securitization allowed it to initiate a greater number of mortgages than if it had relied more heavily on its modest depositor base. When the market for such securitized products dried up, Northern Rock found it difficult to continue writing new mortgages. And without the ability to issue new mortgages, Northern Rock was unable to continue financing Granite, which relied upon the interest income from mortgage payments to pay out securitized notes as they came due. By the end of June 2007, Granite contained £47.8 billion in mortgages.

Ironically, it appears that Northern Rock never saw its troubles coming. In a statement to investors in late July 2007, the bank said that development within the organization in compliance with Basel II, "results in an anticipated regulatory capital surplus over the next 3 to 4 years. This surplus will enable the reduction of previously planned subordinated debt issues and permit capital repatriation of up to £300 to £400 million over this period." Examples such as this demonstrate that financial institutions in general require a deeper grasp of liquidity risk issues – in this case the weaknesses related to inadequate diversification – along with a clearer picture of their current and probable future liquidity risk exposure.

Appendix III

Thornburg Mortgage, Inc.

Thornburg Mortgage, Inc., based in Santa Fe New Mexico, specializes in adjustable-rate, jumbo mortgage lending. [Jumbo mortgages are those that are made to borrowers with good credit ratings in amounts above the \$417,000 ceiling set by Fannie Mae (FNMA) and Freddie Mac (FHLMC)] During the period prior to the subprime crisis, Thornburg was not involved in lending to subprime or Alt-A borrowers (transactions requiring low-doc or no-doc loans), and reports an extremely low percentage of mortgages 60 days or more in arrears. According to a statement released by the company, about 94 percent of the real-estate securities Thornburg owns are rated AA or higher and only 0.23 percent are delinquent, compared with a national average of 2.35 percent. In fact, when news of the subprime first broke, Thornburg believed that the shakeout in lax lending practices would actually benefit lenders with sound market practices, including Thornburg itself.

The problem was that Thornburg, like many other lenders, issued commercial paper (short-term corporate debt with maturities, on average, of about 30 days) to finance home loans. Under normal market conditions this kind of debt can be fairly easily rolled over. However, investors became more risk-averse in light of rising mortgage defaults, causing liquidity to dry up by mid August. Thornburg could find no buyers for its notes, suffering in the same way as other borrowers who could not roll over maturing commercial paper.

In mid August, Thornburg announced it would push back payment of its quarterly dividend to mid September as a result of what it called “liquidity issues.” The announcement sparked a 47 percent plunge in the firm’s share price. In addition, Thornburg was forced to pay down \$8.4b in commercial paper that had been outstanding in June 2007 when buyers demanded “unreasonable” terms to refinance.

The company also paid back about \$12.3bn in lines of credit when it found itself unable to meet lenders’ demands for more collateral, and was temporarily obliged to suspend taking loans applications. By the third week of the month, Thornburg had announced that it had been forced to sell \$20.5bn in mortgage-backed securities (MBS) – at a loss of about 95 cents on the dollar – to pay down its debt. In a public statement, CEO Larry Goldstone stated that, after netting for hedging positions that were also liquidated, the company’s loss would total about \$930m.

At this point, Fitch Ratings downgraded Thornburg’s issuer default rating to ‘CCC’ from ‘BB’, saying the downgrade reflected concern for Thornburg’s ability to generate and maintain adequate liquidity under current market conditions. The ratings agency said the negative watch status reflected the likelihood that liquidity pressures experienced by Thornburg would worsen, should lenders cut off credit or reduce the available credit and advance rates under the repurchase agreements.

The losses incurred by Thornburg in this case illustrate how quickly anxiety over defaults among subprime mortgages can spread to healthier firms. Due to stories such as this, some members of Congress have called for the enactment of regulatory changes that would permit FNMA and FHLMC to buy jumbo mortgages of more than \$417,000, a move that would likely alleviate some of the problems facing Thornburg and similar companies.

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- 1 Some analysts state that these persisting, abnormal spreads could be the result of concern for the creditworthiness of banks due to mortgage-related exposure. However, if this were true, it would seem logical that interbank deposit rates would be strongly differentiated between banks, with a premium placed upon the ones that are most diversified and least exposed to the mortgage sector. This does not appear to be the case.
- 2 This trend is still continuing. For instance, on October 17, 2007 Standard & Poor's downgraded USD 23.4 billion of subprime and Alt-A securities that were created as late as June 2007. Other bulks of mortgage-backed paper were downgraded or placed in MarketWatch Negative in November and December 2007.
- 3 The situation may have been exacerbated by the fact that the United States Federal Reserve Bank tends to maintain low interest rates and abundant liquidity even in an economic growth context, thus encouraging a certain under-valuation of liquidity risk and a lax attitude toward vulnerabilities.
- 4 Real-world case studies have been drawn from the IBM® Algo FIRST for Web Edition on Cloud database. The Algo FIRST for Web Edition on Cloud database contains approximately 7,500 case studies of operational risk, corporate governance, strategic, credit and liquidity risk events. Over 85 financial institutions use the database as content for the monitoring, tracking, and analysis of risks and their associated processes and controls.



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