an equally ready explanation if a stock had moved the other way."
-- Professor Martin Rees, Our Cosmic Habitat (Phoenix 2003, page 101)

But what alternative is there? Although behavioural economists are gaining more and more ground, as far as I can see they haven't presented a replacement model for actual use at the coal-face. I may (and I personally do) have a lot of problems with the strong assumptions behind the work of all the ‘greats’ such as Fama, Modigliani and Miller, and Markowitz, not to mention Milton Friedman, but at least the models they employ underpin the principles of valuation that I need to use when, say, pricing a corporate loan or an interest-rate swap. And it gets even more interesting if I need to set an internal funding rate to reflect the term funding liquidity premium in a bank. What replacement models for such purposes, or adjustments to my current approach, is a behavioural economist proposing? That isn't clear to me.

We have another interesting mix of articles this quarter. Before introducing them, may I reiterate that, as the membership of the CISI to a significant extent reflects the original stock exchange stockbroker and wealth management community, it would be very welcome to see more submissions from individuals employed in this sector. Up to now most articles have received have come from academics or bankers, and while this is certainly very welcome and something we encourage, it would also be most excellent to receive contributions from what is still the core member base of the CISI.

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Our second article is on a topic that describes the core revenue stream of just about every bank in the world, but receives very little airtime. Preserving, and enhancing, net interest margin (NIM) must surely be a primary objective for any bank, so it is an imperative that a bank understands its NIM drivers and stress event impacts. The article by Charlie Hart is a good summary of the key issues in NIM analysis, and understands its NIM drivers and stress event impacts. The article by Charlie Hart is a good summary of the key issues in NIM analysis, and again should be of good value to practitioners.

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I'd like to thank our authors and as usual our readers for their continuing support.

Enjoy the issue.

Professor Moorad Choudhry FCSI, Editor

Never let it be said that financial markets – especially the equity markets as represented by stock indices, such as the FTSE100 or S&P500 – are not emotional things. The instant response to events that, on second thought, might not be as ‘good’ news as they first appear is always interesting to see, because it strengthens the case made by behavioural economists that the perfectly rational investor, a staple assumption of macroeconomic models and thereby also of equity valuation models such as CAPM, is not grounded in reality.

Witness the large gains made by markets in response to the results of the UK general election. Remember that there had been no material sell-offs in the weeks prior to the election, so it’s not as if there was any large ground to make up. But is a Conservative Government with a small majority – in terms of stability and future uncertainty – a better prospect than what preceded it, the coalition with the Liberal Democrats? First of all there is the question of the forthcoming EU referendum, which certain Conservative backbenchers may well be pulling in an opposite direction to compared with the government. And it only takes an odd negative by-election result or two to start slimming that majority. Then of course there are the 56 MPs (out of 59 in Scotland) of the Scottish Nationalist Party, now the third-largest party in parliament. It just goes to show how holding a referendum on something never really kills it off as a contentious subject does it?

But all in all there is much in the UK political scene to contemplate that would make one think that uncertainty and volatility will be increasing, not decreasing, in the next 12-24 months. Some caution is called for, contrary to what one might have concluded just by considering the immediate market reaction.

There are countless examples of the instant impact on equity indices that turned out to be more contra-indicators. I used to think that bond markets were, if not immune, then at least grounded a bit more in logic and ‘fundamentals’ but this isn’t always the case. Many is the time I’ve witnessed the long bond futures contract rise significantly in price in response to a specific news item and then, only a day later, give up its gains and more on no further news. What’s happened in 24 hours that should affect a ten-year yield? (As my old boss at Hoare Govett Securities would have said, ‘more sellers than buyers!’).

It reminds me of this excellent quote from, interestingly enough, a physicist rather than a fund manager or banker:

“People still crave explanations even when there is no underlying understanding about what’s going on...erratic stock market movements always find a ready explanation in the next day’s financial columns: a price rise is attributed to sentiment that ‘pessimism about interest rate increases was exaggerated,’ or to the view that ‘company X had been oversold.’ Of course these explanations are always a posteriori: commentators could offer...
ABSTRACT

In 2014, two major new regulations were introduced with significant implications for banks' liquidity and funding management. The Supervisory Review and Evaluation Process (SREP) by the European Banking Authority (EBA) will take effect on 1 January, 2016, and will adjust the regulatory approach to liquidity and funding as well as require banks to periodically assess their business model, governance/processes, and capital adequacy. The guidelines on harmonised definitions and templates for funding plans of credit institutions, also published by the EBA, include a 'funding template' that financial institutions will already have to complete for the first time by 30 September, 2015. They include above all detailed information on the status quo of assets/liabilities and the regulatory funding ratios liquidity coverage ratio (LCR) and net stable funding ratio (NSFR) as well as forecasts of these positions. Coming from the balance sheet assessment and stress test in 2013/2014, both regulations represent a logical development from a regulatory point of view with regard to the required transparency and an objective regulatory assessment (see Exhibit 1).

In combination, the new regulations can be considered a milestone in the regulatory oversight of banks' liquidity and funding management due to the microscopic approach already known from the evaluation of banks' capital management. This implies, firstly, the collection of data using a specifically designed template; secondly, the application of stress tests designed by the regulator; and finally, the implementation of individual quantitative measures for each bank.

This paper summarises the impact of these two requirements with a focus on liquidity and funding. Additionally, it provides recommendations for the successful implementation.

INTRODUCTION

The financial crisis revealed not only the fragility of the banking sector, but also gaps in its regulatory oversight. Among others, national regulators and politicians across Europe came to realise that they had insufficient knowledge of the assets and liabilities of financial institutions, as well as of the risks hidden in these institutions' balance sheets. This resulted in regulators underestimating the capital and liquidity buffers required in times of a severe crisis. During the financial crisis, numerous banks defaulted, which led to billions in taxpayers' money being spent, as well as a spillover of the banking crisis into the real economy.

To avoid such a negative scenario in the future, the theoretical solution seems simple: regulators must know everything about the banks they oversee, use that information to assess risks by applying rigorous stress tests, and determine the required capital and liquidity buffers for each bank accordingly.

Since a lack of capital in combination with excessive risk-taking was considered to be the main reason for the default of most banks, the regulatory focus was first placed on the required amount of capital.

In 2011, the first EBA stress test was the initial attempt of the regulator to determine the required capital buffers. However, this stress test was, in hindsight, considered to be too mild and insufficient to restore trust in the European banking system. An example of the insufficiency of the first tests is Dexia, which first ran into trouble in 2008 due to a shortage of liquidity, which required a government bailout; and then defaulted just a few weeks after passing the stress test in 2011 due to a write-down of Greek debt, which was not included in the stress test assumptions. The second attempt was led by the ECB as the new prudential regulator. In 2014, the ECB obtained an unprecedented detailed look into the assets and associated risks of banks by performing the ‘Comprehensive Assessment,’ which contained a risk assessment, an asset quality review (AQR), and a stress test. The results of this assessment are (partly) transparent banks whose capital buffers are set by the regulator.

The consequent next step for the regulator is to extend the approach of utmost transparency and quantitative measures to liquidity and funding.

THE NEW SUPERVISORY REVIEW AND EVALUATION PROCESS

On 7 January, 2015, the EBA published the final guidelines for common procedures and methodologies for the supervisory review and evaluation process. Following normal procedure, EBA guidelines are addressed at the National Competent Authorities within the EU, which are required to translate them into national law. However, this clearly defined governance structure was shaken up by the introduction of the ECB as the responsible regulator for major banks. Since the EBA does not have legal authority over the ECB, the ECB is entitled to introduce its own version of SREP. Therefore, some changes or additions can be expected. However, considering the ongoing communication and alignment between the ECB and EBA, the EBA version is usually a very good approximation of the final applicable version of the ECB, and banks are advised to treat the existing version as the status quo and to act accordingly.

SREP can be broadly divided into four tasks the regulator must complete:

- Categorise banks
- Monitor banks
- Evaluate banks
- Decide on potential supervisory or early intervention measures.

The overarching SREP framework is shown in Exhibit 2.

1. Earlier stress tests in 2009 and 2010 were conducted by CEBS
Allocating banks to four categories should ensure that each bank receives the regulatory oversight appropriate for its size, complexity, and systemic risk to the industry. The category will determine how often a complete SREP review is performed by the regulator. The definition of the categories and the matching time frame of the regulatory oversight are shown in Exhibit 3.

The monitoring will be based on a set of ratios to be defined by the regulator. They must include all relevant regulatory ratios (eg, LCR), market-based indicators (eg, credit default swap spreads), and internal ratios (eg, based on recovery plans), which banks will have to report on a quarterly basis. The resulting report will likely largely be a collection of existing ratios that are already known to the regulator. Therefore, the impact will probably be limited.

For the evaluation part, the regulator is required to perform an individual assessment of the bank’s business model, its internal governance and processes, the risk to capital, and the risk to liquidity/funding. The result of each assessment is a score between 1 and 4, which in combination with the other assessments results in the final SREP score of each bank. The final score does not necessarily represent the average of the four individual scores, but is set on an individual basis by the regulator to represent the final assessment. For example, a bank that shows a severe risk of running out of liquidity will likely receive a total score of 4, even though the other scores might all be 1. A final score between 1 and 4 will describe that the bank is viable, while F classifies a bank as failing or likely to fail.

Based on the evaluation, additional measures can be defined by the regulator. These can include quantitative capital measures (eg, additional capital buffers), quantitative liquidity measures (eg, additional liquidity buffers), or other qualitative measures such as enforcing changes to processes or governance. If a bank is classified as failing or likely to fail, the countermeasure is to start the process as defined in the Bank Recovery and Resolution Directive (2014/59/EU), an interaction that highlights the comprehensive approach followed in this SREP version.

Exhibit 2: SREP framework

Extending the Regulatory Focus to Include a Comprehensive Business Model and Liquidity Assessment

With regard to the collection of SREP requirements, there is nothing completely new to the banking world. The novelty, however, lies in the combination of numerous regulatory checks across the entire bank in one comprehensive assessment and score. In this perspective, the final SREP score represents something like the rating of a bank, based on internal data and on-site evaluations. Furthermore, the new system will certainly shift and highlight priorities within the regulatory oversight. For example, the viability of the business model will likely be considered more important. And finally, some tools are introduced, which might change the way the regulator answers existing questions. Focusing on liquidity, the internal liquidity adequacy assessment process ( ILAAP) and liquidity stress tests defined by the regulator stand out as being potentially more comprehensive and more rigorous than common assessments today.

For instance, ILAAP represents a comprehensive evaluation of internal methods and processes, which is already common in some EU countries such as the Netherlands, but which will likely increase the frequency and depth of such checks in other countries.

In recent years, there have been numerous new regulations regarding liquidity and funding; however, the regulatory focus was placed even more strongly on capital regulations. One prominent example to validate this observation is the fact that the capital stress test by the ECB and EBA was based on the assumption of a steady balance sheet and did not include any assessment of potential liquidity default risks.

SREP finally closes this gap by requiring the regulator to design liquidity stress test scenarios for each institution individually. These stress tests can be more severe than the stress test scenario outlined by the LCR ratio and might include a longer timeframe than 30 days. A stress test scenario

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1. Liquidity risk was partly integrated in the calculation of the Net Interest Income in the stress test of the Comprehensive Assessment

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Exhibit 3: Categorisation of banks within SREP
that is more severe than LCR or internal scenarios will have an immediate impact on the volume of the liquidity buffer and therefore on the balance sheet and profitability of a bank. Hence, the application of this new regulation by the regulator is critical for the final impact assessment of SREP.

Based on the results of this external stress test or any other observation made during the assessment, the regulator can set quantitative liquidity measures using three approaches: an LCR ratio higher than 100%, a survival period longer than 30 days, or an increase in the required amount of counterbalancing capacity of available liquid assets. All three approaches consequently lead to an increase in the required liquidity buffer.

**PREPARING FOR SREP**

In a world with unlimited resources, the SREP paper represents a very useful checklist that can be applied for a comprehensive gap analysis of the entire bank, including policies, processes, documentation, and methodologies. Completing such an analysis would yield numerous internal findings that can be closed before the external regulatory test. However, most banks will not be able to allocate the resources for such an extensive project on top of the numerous regulatory projects already ongoing.

However, banks should not leave all findings to the regulator. For example, a lean approach to determine the bank’s status is to set up a series of workshops to discuss the content of SREP, and then have the respective departments—potentially with the assistance of audit—run a first gap analysis.

Furthermore, banks should implement a single point of contact. With SREP and its overarching character, the assessment of the entire bank is performed and steered by one regulatory entry point. To ensure consistency, it is therefore recommended to have one single entry point on the bank side as well. Ideally, this single point of contact would include people with extensive knowledge of the reporting, monitoring, and planning processes of the bank to check all regulatory reporting for consistency.

Finally, existing or new projects should be assessed based on their compatibility with SREP, and that the potential development of an improved data warehouse, triggered by BCBS 239 or the AQR, will be continued. After all, a quantitative microscopic view on a bank is only possible with high-quality data—something that the regulator will surely increasingly demand.

**GATHERING THE REQUIRED DETAILED INFORMATION ON LIQUIDITY AND FUNDING**

The most critical part of an objective and quantitative assessment as intended by SREP is the availability of comparable data to the regulator. So far, such comparable data has not been collected for liquidity and funding—a gap that will be closed with the funding template currently being introduced.

Following the recommendations of the European Systemic Risk Board (ESRB/2012/2), the EBA published the final “guidelines on harmonised definitions and templates for funding plans of credit institutions” on 30 June, 2014. Along with the guidelines, the EBA published a template that must be completed and provided annually by all relevant banks in Europe. The selection of banks will have to ensure that at least 75% of the banking system’s total assets are covered.

Besides a detailed description primarily of the status quo of assets/liabilities and the liquidity ratios LCR and NSFR, banks are also required to submit a one- or three-year forecast. Acquiring this harmonised information enables the regulator to assess potential funding risks in single banks, and offers an unprecedented quantitative comparison of the funding strategies of European banks—both prerequisites for the quantitative evaluation required by the regulator according to SREP.

In 2015, the data must be reported by 30 September with a snapshot date no later than 30 June; from 2016 onwards, the data must be reported by 31 March, with a snapshot date of 31 December of the previous year.

The requirements of the EBA funding template are summarised in Table 1, including an initial estimate of the relative difficulty of gathering the data. However, the actual difficulty for each individual bank depends significantly on the specific planning process already in place and the general quality of data and IT systems. Nonetheless, there are some rules to minimise the necessary time and resources:

- **Focus on the original intention of the template:** The purpose of this template is to provide the EBA with insights into the funding plans, capacity, and risks of single banks as well as the market as a whole. The provided information should therefore answer questions such as “does the maturity profile of a bank show noticeable mismatches; and if this is the case, does the bank have sufficient funding potential to comfortably control this mismatch?” If such questions can be answered, the accuracy of the data can be considered sufficient.

  Taking the data field ‘long-term securities’ as part of the balance sheet forecast as an example. To technically forecast a balance sheet position accurately, International Financial Reporting Standards (IFRS) accounting would need to be applied. Therefore, the IFRS value of each security three years in the future would be required, including the ones that will be issued in the next years. Banks generally do not plan their liabilities at such a level of detail, and it would require a significant effort to adapt the planning process. However, the development of the nominal value of the current portfolio of long-term funding should be easily available from the liquidity maturity profiles, and the volume of the newly issued long-term funding should be known from the funding plan. Based on this information, it is easy to forecast the nominal value of long-term funding in the next three years, which is sufficient to provide the EBA with the necessary information to answer the main questions.

- **Combine the right resources within the bank:** Since it is called a ‘funding template’, it seems obvious that the responsibilities for completing the template should lie within the treasury department. However, treasury departments are sometimes driven by economic steering and less by forecasting specific positions, even if they are as important for funding as deposits, for example. In this specific example, the treasury department needs to know the volume of deposits in three years and their level of sustainability; but it will likely not have this information, since it is not relevant for economic steering if the clients providing the deposits are domestic or internationally based. If the treasury department had to forecast such a position, the results might be not only time-consuming to obtain, but also potentially wrong and inconsistent with other forecasts within the bank.

An adequate approach to solve this issue is to assign responsibility for gathering the required data to the department with the most insight into this specific data field. This would likely include the department responsible for FINREP reporting, the treasury department for funding and liquidity ratios, the finance department for assets forecasts, and the risk department for maturity profiles; even the business units can be consulted to support the preparation of some forecasts. The main challenge is to ensure consistency between different data sources. To minimise that risk, banks could consider to establish the lead or Project Management Office (PMO) for these tasks within the department responsible for regulatory reporting and planning.

- **Do not hesitate to adjust the granularity of your forecasts:** The funding market is a fast-moving market, which is dependent on numerous external factors that can change every day. Therefore, each forecast...
can only be the best possible estimate at a given time. Often, and despite best efforts, reality will differ substantially from the forecasts. The EBA is well aware of this fact and will not use these templates primarily to evaluate the quality of the forecasts but to identify potential risks. Consequently, one should not hesitate to increase the granularity of the forecasts and add the new information based on a best effort approach.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Details</th>
<th>Planning horizon</th>
<th>Estimated relative difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans</td>
<td>Retail Domestic ow. resident borrowers with and without credit provision, mortgage, other; International</td>
<td>3 years</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Corporates Domestic ow. resident borrowers with and without credit provision, SME, large corporates; International</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FI Credit institutions; Non-credit institutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other assets</td>
<td>Cash, reverse repos, derivatives and other assets (no information about securities required)</td>
<td>3 years</td>
<td>Low</td>
</tr>
<tr>
<td>Credit lines</td>
<td>Undrawn committed</td>
<td>3 years</td>
<td>Low</td>
</tr>
<tr>
<td>Intra group loans</td>
<td>Loans to group entities not within the consolidated group</td>
<td>3 years</td>
<td>Medium</td>
</tr>
<tr>
<td>Deposits</td>
<td>Retail Domestic ow. residents; International</td>
<td>3 years</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Corporates Domestic ow. residents, SME, large corporates; International</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FI Credit institutions; Non-credit institutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Securities</td>
<td>Short term (&lt; 1 year) Secured, unsecured</td>
<td>3 years</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Long term (&lt; 1 year) Stock and issuance of unsecured, covered bonds, ABF and other secured</td>
<td>3 years</td>
<td>Low</td>
</tr>
<tr>
<td>Other equity and liabilities</td>
<td>Deposits from group entities not within the consolidated group</td>
<td>3 years</td>
<td>Medium</td>
</tr>
<tr>
<td>Intra group deposits</td>
<td>Deposits from group entities not within the consolidated group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquidity ratios</td>
<td>1 year forecast LCR, 5-year forecast NSFR</td>
<td>1 / 3 years</td>
<td>High</td>
</tr>
<tr>
<td>Specific funding reliance</td>
<td>Deposits Covered/not-covered by Deposit Guarantee Scheme, deposit like retail instruments</td>
<td>3 years</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Public sector Repo funding, credit guarantee funding or credit supply incentive scheme funding</td>
<td>3 years</td>
<td>Low</td>
</tr>
<tr>
<td>Innovative structures</td>
<td>Detailed descriptions and counterpart (total ow. SME, retail ow. client that already own bank deposits)</td>
<td>3 years</td>
<td>Medium</td>
</tr>
<tr>
<td>Pricing</td>
<td>Loans and deposits Retail, Corporates, FI Domestic, international</td>
<td>1 years</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Securities Short term and long term</td>
<td>1 years</td>
<td>Low</td>
</tr>
<tr>
<td>Currency mismatches</td>
<td>Loans, deposits Retail, Corporates, FI Balance sheet items equivalent to main currency without derivative funding</td>
<td>3 years</td>
<td>Medium</td>
</tr>
<tr>
<td>Restructuring</td>
<td>Loans and deposits Retail, Corporates, FI Balance sheet items which are part of a restructuring program (matured, acquired, sold, disposed)</td>
<td>3 years</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 1: Requirements of the EBA funding template

CONCLUSIONS

The increasing number of regulations triggered by the G20 after the financial crisis is expanding continuously and has so far been limited rather by the time and resources available to the regulators than by a conscious decision to limit the regulation. Following the initially set priority of the regulating bodies, the regulatory development started with capital and has now reached liquidity and funding. As expected, the microscopic approach has prevailed, including the collection of predefined data, the introduction of rigorous stress tests, and the option of implementing hard quantitative countermeasures to ensure the limitation of capital and liquidity risk as considered appropriate by the regulator.

The increase in required capital buffers, which already happened but might continue further, and the increase in required liquidity buffers, which will gain momentum through the new regulations, significantly reduces the available resources to earn revenues, and the increase in costs to comply with all the regulations reduces profitability even further.

In order to maintain or even increase their competitiveness under these difficult market conditions, banks can follow these steps:

- Make bold and early investment decisions: While details are still being discussed regarding most areas of regulation, the rough final picture has already taken shape. The regulator will not turn back time and allow banks to operate in the dark, but will continue to demand full transparency on data and processes. The immense costs of the AQR gave a powerful example on the huge burden that can occur if compliance is achieved on an ad-hoc basis. Therefore, investing in, for example, the implementation of a data warehouse that can be used to comply with all regulatory requirements will require high investments today, but will deliver significant cost savings later.

- Engage with the regulatory world: Sadly a not uncommon approach when dealing with the regulator was to keep it in the dark as far possible, in order to run the business without regulatory intervention. While still pursued in some banks, this option is no longer practicable in the new world, since the microscopic regulatory view will likely detect any irregularities or extensive risk-taking sooner or later anyway—and if detected, the negative consequences will likely outweigh the initial positive business impact. Rather than considering the regulator an enemy that they should endeavour to keep out, banks should embrace the new world by considering him an objective friend, who can help you to run your business in a way favourable for your long-term economic development. Setting up transparent processes and having transparent data readily available increases not only the trust of the regulator in the bank, it also enables better steering for the management and in general reduces the likelihood of quantitative measures introduced by the regulator that are not economically useful or justified.

- Streamline internal organisation: Not being compliant or not fulfilling the economic expectation of the regulator with regard to capital or liquidity buffers likely results in very expensive countermeasures or penalties. However, even being compliant can be very expensive. Once, fulfilling the requirements and gathering the necessary data can cause high operational costs; secondly, the regulator must be convinced that the current set of processes and methods along with the calculated buffers are suitable for the bank. Otherwise, the regulator might demand an increase in the buffer capacity due to the lack of understanding or lack of trust in the risk management of the bank. To reduce these risks, it is recommended to implement a strong PMO, which always acts as the first contact to the regulator. Ideally, the PMO -is capable of answering many questions of the regulator themselves; at least, they must be capable of directing the questions instantly to the right person or department. Furthermore, they should keep track and be aware of all data provided to the regulator to assess and ensure consistency.
A PRIMER ON NET INTEREST INCOME MODELLING, FORECASTING AND STRESS TESTING

Charlie Hart, who consults worldwide on best practice in risk management. He is a Certified Financial Risk Manager from the Global Association of Risk Professionals and earned an MBA from the University of Chicago's Booth School of Business.

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ABSTRACT

Net interest income (NII) modelling is a crucial tool in the risk manager's kit. A robust forecasting model with assumptions around future stock levels may provide the basic assumptions for a NII model. The same model can be expanded into a stress testing tool, offering insights into sensitivities to factors, such as market rates or customer behaviours.

NII indicates expected profitability, and the therefore informs future capital levels. Enhancing the NII model to incorporate capital raising, dividend payments, and credit events including losses given default, will assure integration of credit and market risk views. The same model will reveal liquidity levels and costs of said liquidity. A savvy modeller will incorporate distress factors influencing the liquidity of both assets and liabilities.

WHY NII?

For balance sheet managers (BSM), modelling income from the balance sheet has become as relevant as the market value and duration of equity when reporting to management, including the Asset Liability Committee (ALCO).

From a P&(L) perspective; the BSM adds value through hedged interest income from the banking book. Valuation and the moments of sensitivity to rate movements (BPV and convexity) of held to maturity banking products therefore should matter less. Essentially, the earning potential of the leveraged equity in the balance sheet is a better measure of the value of the enterprise than the implied market value of the same equity (MV Assets-MV Liabilities). Many ALCOs now focus more on NII, although policies typically govern limits on both value and income.

Present value calculation requires predicting the size and timing of principal cash flows of customer deposits with indeterminate maturity and volume. Then both the first and second derivative of market value are highly dependent on the initial assumptions of dates for principal cash flows for deposits, hence the implied market value, duration and convexity of equity are also are difficult to read with confidence. In contrast, predicting the interest expense by a pool of customer deposits can be done with more confidence.

Net interest income generated ex ante by the model can be benchmarked to the same net interest income, ex post, as reported in the general ledger, over the same period. There is simply no way to similarly benchmark the market value of the entire balance sheet.

Net income analysis reveals more than just pro forma profitability, it can indicate capital and liquidity sufficiency too. Alternative assumptions and stress scenarios around behavioural cashflows (early withdrawal of deposits, forced sales of collateral, and disbursement of unfunded credit lines) for liquidity and credit events (increased defaults and/or reduced recoveries) for capital, as well as other adjustments to the main NIM model allow for an efficient alignment of reporting processes.

TERMINOLOGY

Net interest margin (NIM) measures the difference in % between the interest-based revenue generated by the bank and the interest expense paid out to its bondholders and depositors. As such, it ignores the balance sheet effects liquidity management, of equity funding or capital growth. As it is relative and not absolute, it allows for a comparison of profitability for balance sheets of different sizes.

As this number excludes the impact of derivatives on income it is less relevant to the BSM than NII. Because NIM is not an absolute measure of currency income, it is also less useful when attributing P&(L).

NII is the sum of the revenues generated by interest bearing assets, the expense of interest paid on liabilities, and net interest received and paid on derivatives (including swaps, caps, floors) over a given term. Shocking said net income with rate shocks gives a measure of rate risk for a given balance sheet; NII sensitivity. This number will include the impact of buying assets (distressed bonds) or issuing debt at a discount (for example commercial paper) on interest income per GAAP.

Over a given term, how much income will accrue to shareholders, NII + costs incurred + fees charged + gains (losses) on MTM assets, taxes? This is the shareholder value added (SVA).

Reported statutory and tax balance sheets and income will include additional non-interest based revenue/costs, operating charges, dividends, tax credits and debits. These parameters can be introduced in a robust model for NII to report true SVA.

FORECASTING

Unlike market value-based measurements, forward looking views of the balance sheet require more assumptions around growth, funding and reinvestment. By designing forecasting model with stress testing in mind, BSMs can derive sensitivities to underlying assumptions and exogenous factors. A framework such as the one offered by QRM (qrm.com) is useful for managing and applying these assumptions in a controlled manner.

Vended frameworks also have the advantage of offering reporting interfaces.

For a given day, the coupons, maturities and notional provide sufficient detail to model a balance sheet's net income. If the focus is consolidated interest income, then ideally intercompany positions which consolidate out (funding or hedging positions) are excluded from the population of transactional data. Creating pools from transactions will lead to more efficient analysis, with ideally minimal loss of precision.

Quickly, however, the current position seasons and is no longer sufficient to model NIM beyond a single day's simulation. By the close of business, some loans and deposits will have matured, loan balances amortised (and prepaid), and deposits decayed. Forward settlement of transactions (such as swaps, but also loans and debt) with terms agreed upon until today will also factor into the following days' analysis, as these will appear on balance sheet with relevant funding effects. These principal effects have material impact on the balance sheet and must be resolved. Moreover, given a typical day of activity, balances of receivables, payables, and retained earnings will fluctuate and therefore impact the sources and uses of funds that drive balance sheet.

Obviously, interest earned or paid will also vary for variable rate products, so it is critical that reset dates, margins, intervals, underlying rate indices, are fed into the model. As the forecast will also include new fixed-rate products, their coupons will likewise be a function of prevailing market rates and assumed spreads. If margins are administered (not constant) then the model should accommodate.

Behavioural cash flows, ie, prepayment of loans and decay of customer deposits, are quite relevant to NII modelling, in that both existing and forecasted transactions will show curtailment and resulting impairment.
of yield due to prepayment. As these behavioural products are typically hedged by contractually amortising hedges, the NII framework can also reveal the sensitivity due to fast pay/slow pay risk. If actual prepayments are lower (higher) than expected then the assets are under (over) hedged, this will have a material effect on NII sensitivity. As such the BSM is advised to back test assumptions around behavioural cash flows and to assess impact of error in forward estimation on NII.

That hedges don’t necessarily perform as designed illustrates the primary reason for modelling assets and liabilities separately from derivatives, as opposed to modelling them net of hedges. Moreover BSMs may elect to leave fixed positions open, or use swaps to take on extended duration of portfolio: creating net structural positions. Similarly, modelling derivatives discretely is critical to replicating the effect of these strategies in the forecast over the long term.

As sources of funds mature or decay, are they expected to be replaced like for like or will short term funding be preferred? Similarly, as assets amortise, will new assets originate like for like or will cash accumulate instead? In effect, the size of the balance sheet may shrink, remain steady or grow, depending upon the requirements of stakeholders.

Funding plans (including campaigns for deposits, expected debt issuance), budgets and forecasts from business unit-level indicate to BSMs both origination and stock expectations for notional products. Spreads as well as basis can be retrieved from these same projections, to be consistent with other management information (MI) in the organisation. As such, the NII analysis can build upon the relevance of the existing processes within the bank; ensuring engagement while offering challenge.

Balance sheet managers may also elect to bring in loans (primarily mortgages, but also fixed unsecured loans) with only applications in a pipeline. As these are already hedged with amortising pay fixed swaps, if the pipeline is not modelled with same assumptions used to hedge them, then NII sensitivity will result from rate movements. This may be desired, however, if the consensus expectation of prepayment has changed, post hedging.

Non-performing loans, as well as expected default and recovery of currently performing loans, may also be incorporated to better inform analysis of lending portfolio. Dividend payments that deplete capital and stock issuances that increase capital (including conversion of hybrid sources of funding) should also be incorporated in the model, which now offers insights to managements as well as regulators regarding capital sufficiency.

**STRESS TESTING**

Given shocks to certain parameters in the forecast model, what will the impact be on NII, and therefore capital? How will compliance with liquidity ratios be achieved? The model used to forecast should be sufficiently robust to allow for stressing of factors in a tractable and efficient manner.

As rate risk remains a primary concern for NII, a range of rate scenarios ought to be applied against the forecast when reporting NII sensitivity. As a central case, practitioners may choose to assume that rates remain static throughout forecast period. Others prefer an implied forward view, based on the same projections of term structure implied by expectations hypothesis and used in present value analysis. As the assumptions from the business units’ budget/forecast are based on in-house assumptions around market factors, it is useful to apply these inside of a NII analysis as well to validate revenue/expense numbers from balance sheet model against those from business units.

Other market factors, including CPI, home price inflation and FX rates can also factor into NII analysis. Typically, BSMs will shock rates up and down by 50 and or 100 bps in order to assess rate sensitivity. By using shocks in both directions in varying magnitudes, local aspects of sensitivity can be established. Additional scenarios, based on events of concern (sovereign default, election, etc) are expected to move markets.

NII models allow for divergence of factors which are assumed to be positively correlated in typical MV/BPV analysis. For example, typical parallel shock analysis would presume that all yield curves move up or down simultaneously, however, recent market activity has shown Central Bank and LIBOR cash rates diverging. A steeper or flatter yield curve will also have different results, assuming that the assumptions around pricing are also driven by a variety of term points (new debt issued at five-year term point, loans indexed at six-month LIBOR rate, mortgages hedged back to three-month LIBOR). This expansion or compression of basis is a unique selling point of NII analysis.

Finally, to assure comparability in MI from month to month and year to year, these scenarios should be portable as markets progress through time. Has the NII sensitivity to the same steepening scenario changed from last month to this month, for example?

Changes in interest rates will obviously change rates for variable rate products as well as the coupons of forecasted new business. However, the secondary effects of rates on other aspects of the NIM model are worth noting. For example, a downward shock on rates will propagate more prepayments on a fixed-rate loans, as customers are more inclined to refinance loans. Loans in the pipeline are less likely to originate, as new customers are better served in new rate environment by other lenders. Any other originations will be made at prevailing (lower rates). As customers see reversion to SVR rates after fixed periods, these lower rates (possibly partially offset by expanding corresponding margins) will also like decline, reducing revenue further. Credit facilities may see greater disbursements of notional, at lower yield, also impairing profitability. Prepayments will accelerate.

Lower rates will see a reduction in decay for term deposits. Customers with current accounts already earning no interest will be unaffected, however those who are enjoying deposits with administered margins may see their margins expand relative to underlying market rates in order to defend market share.

The BSM therefore will need to apply assumptions around both balances and margin behaviour, given market conditions which are perhaps beyond the scope of the business unit’s forecast. How would a 0% base rate affect premium savings products? Will SVR track base rate with a stable margin or would margins change given movements by the Bank of England Monetary Policy Committee?

Conversely, given an upward shock, the same administered margins for deposits would be compressed given competitive pressures. Prepayment of loans would likely slow and more applications in pipeline are likely to complete.

A sufficiently large rate shock may even increase interest expense for current accounts which otherwise are assumed to not pay interest at all. Large upward shocks conceivably could increase defaults for all loans (not only fixed products) as customers will likely face greater financial distress from all obligations (fixed customers may be distressed by servicing commitments to third party banks, leading to defaults on fixed commitments as well as floating. Perversely, said distress may cause larger disburse of credit, despite increased costs.

The forecasting framework should also reveal impact of stresses on balance sheet due to increases in behavioural cash flows. For example, if mortgages stopped prepaying while depositors withdrew funds, the bank may be challenged to provide sufficient liquidity to handle redemptions with cash on hand. Forced sale of assets or even calling on credit facilities may be required in order to remain solvent. Regulators are now asking the relevant questions about preparedness for these stresses.
Beyond the predictability of customer behaviour, limiting availability of liquid sources given stress may also be of interest. As events of 2008 showed, deep and liquid markets with low spreads, such as those for repos and commercial paper, can quickly dry up and offer little funding at even large spreads. Given a similar disruption, how will the bank secure funding? Are there credit facilities negotiated and ready to be called upon in order to raise cash, what would the impact be on NII and capital? Will active repurchase agreements allow for sufficient cash on hand to meet regulatory requirements given these other stresses?

Defaults similarly are of interest to both management and regulators. A stress could arise from an increase in defaults, and or a reduction in recoveries for retail lending. For commercial banking, the impact of specific counterparty’s defaults should also be a concern, given collateral and other credit enhancements such as credit default swaps.

If the lending book is highly concentrated in a given sector or region, the increase in defaults across the given sector or region may be another relevant way to stress the balance sheet. Once distressed, creditors typically draw down available credit facilities, and therefore maximise the bank’s exposure before moving into default. Hence, the peak exposure at default is higher than the current notional of lending outstanding.

As stress testing will require margins, prepayments, disbursement of lines, default and recovery be driven by stressable factors, a robust framework (whether purchased or developed in house) for forecasting will allow the balance sheet manager to project NII given stresses to any number of factors at a variety of directions and magnitudes. This in turn will allow for a more robust indication of sufficient capital and liquidity over the same forecasted period, using consistent assumptions.

Exhibits 1 and 2 illustrate the output that would be incorporated in monthly ALCO MI.

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**AN ANALYSIS OF THE FORWARD VOLATILITY AGREEMENT**

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**ABSTRACT**

Variance, volatility, forward volatility swaps and other variations of derivatives based on volatilities have become popular and are used mainly by hedge funds and banks managing exotic derivative trading books. A forward volatility agreement is a forward contract future spot implied volatility, and in this paper we will provide an analysis of such instruments, their construction and pricing.

1.1 FORWARD VOLATILITY AGREEMENT (FVA)

The forward implied volatility of an exchange rate return can be defined by forward volatility agreement (FVA – not to be confused with ‘funding value adjustment’, which is something else entirely in the world of financial derivatives). The FVA is a volatility swap contract between a buyer and seller to exchange a straddle option at a specified date in the future and at a specified volatility level.

A long (short) straddle involves buying (selling) both a call and a put option on the same underlying at the same strike price and for the same expiration date. Option players who have a view on volatility usually take a position on straddle trades. A long straddle position is a bet that the underlying will be more volatile over the term of the instrument than predicted by the market.

A forward volatility agreement can also be defined as forward contract on future spot implied volatility, which for a one dollar investment delivers the difference between future spot implied volatility and forward implied volatility.

In other words, the FVA is a forward contract on a future spot implied volatility, with a payoff at maturity equal to:

\[
(IV_{t+k} - FV^k_t) x M
\]

Where

- \( IV_{t+k} \) is the annualised spot implied volatility observed at time \( t+k \) and measured over the interval \( t+k \) to \( t+2k \)
- \( FV^k_t \) is the annualised forward implied volatility determined at time \( t \) for the same interval starting at time \( t+k \)
- \( M \) is the notional dollar amount that converts the volatility difference into a dollar payoff.

For example, setting \( k=1 \) month implies that \( IV_{t+k} \) is the observed spot implied volatility at \( t+1 \) month for the interval \( t+1 \) month to \( t+2 \) months.

The implied volatility is a measure of expected volatility, which is directly quoted in traded currency options.

‘Spot’ implied volatility is the implied volatility for an interval starting today and ending in the future (e.g., starting today and ending one month from now).

‘Forward’ implied volatility is the implied volatility determined today for an interval starting in the future and ending further in the future (e.g., starting in one month and ending in two months from now).

The key motivation for trading FVAs is that it allows investors to speculate on the level of future volatility. Similar to the standard carry trade, the
volatility carry trade is a speculation strategy that buys and sells FVAs, where investors try to make money by guessing the level of future spot implied volatility. The carry trade in volatility works well if spot implied volatility is unpredictable. Then, investors engaging in this new carry trade will on average earn the difference between spot and forward volatility without having to worry about movements in exchange rates.

Given the data on the current implied volatilities for alternative maturities, the calculation of forward implied volatility can be computed (as a proxy) by a simple formula, which assumes that the relation between implied variance and time is linear across the term structure.

Define \( \sigma_{T1} \) and \( \sigma_{T2} \) as annualised at-the-money (ATMF) implied volatilities for the interval \( t \) to \( T \) and \( t \) to \( T \) respectively, corresponding to yearto-year fraction \( D_{T1} \) and \( D_{T2} \). The forward implied volatility between the two dates \( \sigma_{T1T2} \) is determined as follows:

\[
\sigma_{T1T2} = \sqrt{\frac{\sigma_{T1}^2 D_{T2} - \sigma_{T2}^2 D_{T1}}{D_{T1} D_{T2}}} \tag{1.1}
\]

\( \sigma_{T1T2} \) is the market-determined forward implied volatility, which is known at time \( t \) and corresponds to the interval between \( T \) and \( T \).

It is therefore possible to infer the 'local' volatility between two points \( T \) and \( T \) given the spot volatility curve.

For example, if current three-month and six-month volatilities are trading at 10% and 15% respectively, the three-month forward volatility would be 18.71% as per the above equation.

The above relationship can be used to calculate forward volatilities for the entire volatility surface. However, this calculation does assume that skew in absolute (fixed) time is fixed.

### 1.2 FINANCIAL ENGINEERING – FVA CONSTRUCTION

The buyer of a forward volatility agreement enters a contract to buy at specified future date 'fixing' date, an OTM straddle maturing at a date after the start or the trade date of the straddle strategy. The volatility level of the OTM straddle is agreed initially such that there is a zero cost to enter into the strategy. For example, the quoted volatility for the FVA is the forward volatility level that gives a zero cost.

The strike of the straddle is fixed to the date on which the term of the options begins, and at the same time the forward spot is set for the exercise date of the straddle. The premium of the forward volatility agreement is also calculated and paid on the forward date.

The amount paid for the forward volatility agreement is calculated as follows:

\[
pay = \sum_{T1}^{T2} \left[ \mathcal{N}(\sigma, \sigma_{fix}) - \mathcal{N}(\sigma_{Straddle}) \right] \tag{1.2}
\]

Where

- \( \mathcal{N} \) is the cumulative normal distribution.
- \( \sigma \) is the current volatility,
- \( \sigma_{fix} \) is the agreed volatility,
- \( \sigma_{Straddle} \) is the value of the options.

The calculation rule is applied only if the horizon date is before or on the forward date. If the horizon date is after the forward date, the value of the forward volatility agreements is zero.

The following formula provides the value \( vFVA \) for a purchase of a straddle for the forward date:

\[
vFVA = \sum_{T1}^{T2} \left[ \mathcal{N}(\sigma, \sigma_{fix}) - \mathcal{N}(\sigma_{Straddle}) \right]
\]

Where

- \( s(t) \) is the spot price of the underlying of the straddle,
- \( r(t,t) \) is the risk-free interest rate for the period \( t \) through to \( t \),
- \( q(t,t) \) is the dividend rate for the period \( t \) through to \( t \),
- \( \sigma_{fix} \) is the volatility agreed on the contract date,
- \( \sigma(t,t,T) \) is the forward volatility at time point \( t \) for the period \( T \) through to \( T \).

\[ N(x) \] is the cumulative normal distribution.

Continuous compounding is used for interest rate \( r \) and dividend rate \( q \); yield curve \( r(t,T) \) is used for forward rate \( r(t,T) \), in which \( t \) is the evaluation date. The current forward volatility is calculated as follows:

\[
\sigma(t,t,F,T) = \sqrt{\frac{\sigma^2(t,F,T) - \sigma^2(t,F)}{T - t}}
\]

This is the same as equation (1.1). Only slightly different notation has been used.

If the underlying of the straddle is an exchange rate, \( r \) is the risk-free interest rate for the local currency, and \( q \) the risk-free interest rate for the foreign currency.

The calculation rule uses the Black-Scholes formula for pricing options. This formula first prices the components of the straddle - the call and put options - by using the forward interest rates and the current forward volatility. The values for the straddles are totalled and discounted, and the option premiums are deducted. This results in the calculation rule shown above for forward volatility agreements, in which the premium of the term is given by the fixed volatility \( \sigma_{fix} \).

### 1.3 VARIATIONS

Effectively an FVA is a forward contract struck with a specified implied volatility. Therefore, on the trade date both parties agree on: a reference forward volatility (strike volatility), a strike fixing date and an option expiry date. Interestingly for a financial derivative, the contract can be cash settled or 'physically' settled.

**Physical settlement**: On the strike fixing date the seller of the contract receives a cash premium equal to the Black-Scholes (BS) price of the option calculated using the agreed strike volatility in exchange for the option itself.

**Cash settlement**: On the strike fixing date the contract is settled with payment of the difference in premium between the BS price of the option using the strike volatility and the prevailing market volatility.

Variations of FVA contract are currently restricted to the definition of strike of the straddle. Typical variations are ATM Forward or the delta neutral straddle strike for standard Black-Scholes delta or for Black-Scholes delta with option premium included.

If the strike of the straddle is defined as a Delta Neutral straddle, this implies that the strike is solved for such that the aggregate delta of the straddle is zero.
Consider a situation where one believes the implied volatility for a given currency on a given tenor will be higher at some point in the future. For example, three-month EUR-USD will be higher three months from now. One can then enter into a 3*6 forward volatility agreement for a notional of $100,000. Assume that the agreed forward volatility level at inception of the contract was at 10%. There is no premium paid at this stage. Thus we have:

- **Contract date:** 01/18/2012,
- **Settlement date:** 04/18/2012,
- **Maturity:** 07/18/2012,
- **Currency:** EUR-USD,
- **Notional:** 100,000,
- **Contract:** FVA,
- **Tenor:** 3*6 (3 month option in 3 month time),
- **Agreed volatility:** 10% (the FVA rate).

### Contract date: 01/18/2012 (t0)

- We enter into a 3x6 FVA Contract paying Fixed FVA rate of 10%
- **Notional:** = 100,000 USD
- **No upfront Premium**

### Settlement date: 04/18/2012:

- On settlement date (t+k) if the three-month Implied volatility is 11%, then:
  - The deal settles into ATMF Straddle position with notional of say 25M per leg
  - The premium to pay for this straddle is then EUR% 3.9847 (three-month Straddle priced at 10% volatility)
  - If the observed implied three-month volatility on settlement date is 11%, the position could be closed out immediately at 11% volatility level which corresponds to EUR% 4.3839 (Straddle premium priced at 11% volatility)
  - Recall the FVA payoff:

\[ \text{pay off}_{FVA}(N, \sigma, \sigma_{fix}) = N \left( V_{\text{straddle}}(\sigma) - V_{\text{straddle}}(\sigma_{fix}) \right) \]

  - The net profit if cash settled is: 25M x (0.043839 – 0.039847) = approximately, 100,000.

### GENERIC OPTION VALUATION PRICER - BLOOMBERG

If we look at a recent implied forward volatility that commences three months from now and expires three months later, we can see from the table below that the 3x6 for EURUSD quote is: 11.541%. Even though the market quote for future date is unknown, the current volatility surface can be used to extract future or instantaneous volatilities.

<table>
<thead>
<tr>
<th>Currency pair: EUR-USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade date: 04/30/2012</td>
</tr>
<tr>
<td>FVA date: 07/30/2012</td>
</tr>
<tr>
<td>Expiry date: 10/30/2012</td>
</tr>
<tr>
<td>Notional: 100,000,000</td>
</tr>
<tr>
<td>Not.currency: EUR</td>
</tr>
<tr>
<td>Agreed vol: 11.574%</td>
</tr>
<tr>
<td>Market vol: 11.574% (3x6)</td>
</tr>
</tbody>
</table>

To simplify the example, we can set the agreed volatility strike the same as the market extrapolated volatility for the tenor of FVA contract. Then we use the FVA template in Bloomberg’s OVGE screen. We enter the trade date, Domestic and Foreign currencies, the FVA date and the final expiry of the contract. We solve for the volatility strike that produces zero price (as close as possible). One limitation with OVGE is that it does not have solver functionality and this is mainly due to the correlation between spot and volatility. The dynamics of the observed volatility surface when spot moves is inconsistent with the result from stochastic volatility models.

### Table 3

As expected when using stochastic volatility models, the model tends to undervalue the market price or quoted prices, and this is mainly due to the correlation between spot and volatility. The dynamics of the observed volatility surface when spot moves is inconsistent with the result from stochastic volatility models.

To hedge the above FVA contract:

- Enter long three-month EUR-USD Straddle position on EUR 10,000,000 notional; and
- Enter short three-month EUR-USD Straddle position on EUR 10,000,000 notional.

The net position should leave us a long three-month long Vega. On the trade date, the position should have zero Delta and Gamma but we with constant Vega as spot moves from trade date until the contract (FVA’s) start date.

We can maintain constant Vega until the FVA date but once the FVA date is reached, the position will have regular Vega position as Vanilla option and will need to be risk managed. As the market moves, the strike is then away from the DNS (Delta-Neutral Straddle). To maintain the Delta neutrality of the position, the trader needs to buy/sell the underlying.

As mentioned above the FVA contract does not need to be delta hedged before the forward starting period ends. However, such contracts need to be Vega hedged with vanilla, out-of-the-money Straddles (as they do have zero Delta and Gamma). A long OTM straddle has to be purchased on the expiry date of the option (six month), while a short OTM Straddle has to be sold on the strike fixing date (three month). As the spot moves, the delta of these Straddles is likely to move away from zero, requiring re-hedging of the position, which increases the costs (which are likely to be passed on to clients) and risks (unknown future volatility and skew) to the trader.
From inception of the contract until the FVA’s date, we maintain a constant Vega position. Given the above portfolio of vanilla positions, we then risk manage the Delta/Gamma risk, Vega risk, as well as the Vanna and Volga risk.

**DELTA RISK:**

\[
\text{CallOption} = S x N(d_1) - K e^{-rT} N(d_2)
\]

\[
\text{PutOption} = -S x N(-d_1) + K e^{-rT} N(d_2)
\]

where

\[
d_1 = \frac{\ln(S/K) + (r + \frac{\sigma^2}{2})T}{\sigma \sqrt{T}}
\]

\[
\text{Delta} = \phi(d_1)
\]

To maintain the delta neutrality of the position after the FVA’s date, we need to buy/sell an amount equivalent of the delta of the position.

**STRIKE-LESS VEGA**

Both Volatility Swap and FVA’s initially give exposure to strike-less Vega (exposure to implied volatility that remains constant as spot moves). This is because the ATM straddle is not set until after the FVA’s fixing date /start date. The FVA’s strike-less Vega is constant until the strike-fixing date and once the strike is fixed at fixing date of the FVA, the Vega profile is similar to Vanilla and varies with the underlying.

**RISK MANAGING THE GAMMA OF VOLATILITY EXPOSURE (‘VOLGA’)**

Volga represents the sensitivity of Vega to a change in implied volatility. It is given by:

\[
\text{Volga} = \frac{\sigma^2 S^2 P}{\sigma \delta^2}
\]

- The first derivative of Vega with respect to a change in volatility.
- The second derivative of option value with respect to a change in volatility (hence its other name is Gamma Vega).

The Volga is also referred to as Vomma. For volatility movements, Volga is to Vega what gamma is to delta (for spot movement).

For complex exotics such as FVAs that require stochastic volatility models, one needs to compute Volga and other Greeks with respect to model parameters.

The interest of Volga is to measure the convexity of an FVA position with respect to volatility. An FVA contract with high Volga benefits from the volatility of volatility! Hence, volatility dependent derivatives such as FVA with substantial Volga, pricing with a stochastic volatility model with high volatility of volatility may change the price dramatically.

For complex exotics such as FVA, traders cannot simply ignore the risk due to the change of Vega. They have to understand the change of the Vega with respect to the spot (see Vanna) and to the volatility itself. And to have a better understanding of Volga, it is important to stress the variety of models to account for the smile surface. In particular, the shape of Volga would crucially depend on the choice of model out of the following list of models:

- Stochastic volatility models: the correlation effect between the stock and the volatility plays an important role in shaping the Vega change.
- Local volatility model where the resulting local volatility is a function of the underlying itself.

- Jumps models with jumps correlated to the volatility parameters.
- Combination of the above, like Lévy processes.
- Discrete type option pricing models that are in fact, discretised versions of the models above. For instance ARCH/GARCH processes are just discrete versions of stochastic volatility models.

**RISK MANAGE SKEW EXPOSURE (‘VANNA’)**

Vanna measures the change in Delta due to a change in volatility. It measures the size of the skew position. Vanna is the slope of Vega plotted against spot.

The Vanna is a second order ‘cross’ Greek. Like any other cross Greeks, the Vanna can be defined in many ways, as follows:

- First derivative of Vega with respect to a change in the underlying.
- First derivative of Delta with respect to a change in volatility.
- Second derivative of option value with respect to a joint moved in volatility and underlying.

To account for the complexity of the smile and in particular its skew and convexity, one needs to apply more realistic models including deterministic local volatility, stochastic volatility and jumps (see smile modelling), and most recent model that combines both Local Volatility and Stochastic Volatility models (SLV). Stochastic models can change considerably the shape of the Vanna as they explicitly specify the correlation between volatility and the spot. If spot and volatility are positively correlated, the holder of the option with positive Vanna will benefit from the correlation.

**VALUATION MODELS**

Volatility swaps and forward volatility agreements are more complex instrument to price. Volatility is the square root of variance, and is a more complex derivative of variance. Its value depends not just on volatility, but on the volatility of volatility, and you have to dynamically hedge it by trading variance swaps as the underlying. This is possible too, but needs a model for the volatility of volatility. The selected model should be able to produce realistic hedge ratios or Greeks such as Delta, Gamma, Vega, as well as Vega risk with respect to changes in both spot and implied volatility.

**LOCAL VOLATILITY MODEL (LV)**

The Local Volatility Model (LV) extends the Black-Scholes model by allowing the instantaneous volatility to depend on spot and time (Dupire 1994).

\[
dS = S_t(r_t - q_t) + \sigma(t,S_t)S_t dW
\]

The Local Volatility function \(\sigma(t,S_t)\) is a function to be inserted into the (1.3) which will reproduce the current vanilla market prices. The function has no stochasticity of its own, just deterministic state dependency on time and underlying. This model class is considered less simple since it does not involve individual stochastic differential equations (SDE) for the volatility, it is merely described by a function.

Dupire found that the Local Volatility (LV) function could be derived as:

\[
\sigma(K,T) = \sqrt{\frac{\delta C}{\delta K} + (r - d)K \frac{\delta C}{\delta K} + dC}
\]

The advantages of the LV model are:

- Simplest model consistent with the market
- Local volatilities are forward volatilities
- Arbitrage free (positive and regular)
STOCHASTIC VOLATILITY MODELS

The first stochastic volatility model was proposed by Heston in 1993, who introduced an intuitive extension of Black and Scholes. He assumed that the spot price follows the diffusion: that is, a process resembling geometric Brownian motion with a non-constant instantaneous variance \( V(t) \). Furthermore, he proposed that the variance is a CIR process, that is a mean reverting stochastic process of the form:

\[
\begin{align*}
\frac{dS_t}{S_t} &= (r_d - r_f)S_t dt + \sqrt{V_t} S_t dW^1_t \\
\frac{dV_t}{V_t} &= k(\Theta - V_t) dt + \sigma \sqrt{V_t} dW^2_t
\end{align*}
\]

And the two Brownian motions are correlated with each other:

\[d(W^1_t, W^2_t) = \rho dt\]

1. Initial volatility: \( V(\theta) \), Not directly observable
2. Long term variance: \( \Theta \)
3. Speed of mean reversion of volatility: \( k \)
4. Volatility of volatility: \( \sigma \)
5. Correlation between spot exchange rate and volatility: \( \rho \)

All these parameters can be calibrated.

We can interpret the parameters \( \sigma \) and \( \rho \) as being responsible for the skew, the volatility of variance controlling the curvature and the correlation the tilt.

The other three parameters (\( V(\theta), \Theta \), and \( k \)) control the term structure of the model, where the mean reversion controls the skewness of the curve from the short volatility level to the long volatility level.

Taking the limits \( \sigma \rightarrow 0 \), and \( k \rightarrow 0 \), we recover the Black-Scholes PDE with constant volatility.

The volatility-of-volatility and mean reversion have opposite effect on the dispersion of volatility. Volatility-of-volatility allows a large variation of future values of volatility; Mean-reversion reversion tends to push future values of volatility towards the long-term value of volatility.

STOCHASTIC LOCAL VOLATILITY MODEL

Because of the limitations of the Local and Stochastic models on their own, recently the market practitioners have settled on using a model that combines both of the above models called Stochastic Local Volatility model (SLV).

At the moment there is a dearth of empirical tests on valuations of volatility derivatives (products) using this new approach, however, implementation and tests on barrier type exotics show:

- calibration matches the entire volatility surface to the very distant wings
- better model generated prices for reverse KO, Touches and Digital
- consistent with market dynamics.

For valuation of FVA, it would require a model that has the above features. It will also require not only better calibration but the calibrated volatility surface should have correct dynamics.

To test the SLV model, we would need to generate list of FVA prices for a given maturity using various mixing fractions. We can then compare these prices with market quoted prices (provided there are liquid OTC prices). For more detailed discussion on the implementations and empirical result on the SLV model, see Tataru and Fisher, (2010).

The SLV model is described by:

\[
\begin{align*}
\frac{dS_t}{S_t} &= (r_d - r_f)S_t dt + L(S, t)\sqrt{V(t)} dW^1_t \\
\frac{dV_t}{V_t} &= k(\Theta - V_t) dt + \sigma \sqrt{V_t} dW^2_t \\
dW^1_t \cdot dW^2_t &= \rho dt
\end{align*}
\]

\( L(S_t, t) = \) Local Volatility, \( K = \) speed of mean reversion, \( \Theta = \) mean reversion level, \( V_{vol} = \) volatility of variance, \( P = \) correlation.

The mixing of LV and SV features is controlled mostly by \( \sigma V_{vol} \), followed as importance by the correlation \( \rho \). For SLV to degenerate to a pure LV model one would set \( V_{vol} = 0 \) and to obtain a pure SV model one would set \( L(S, t) = 1 \).

SUBMISSION GUIDELINES

CISI members are invited to submit to the Institute for consideration papers on any aspect of wealth management, capital markets and banking.

Articles must be:

- Original work and previously unpublished
- Between 1,500 and 3,500 words in length and accompanied by an Abstract of 80-150 words.

All papers submitted will be refereed by the journal editorial panel or its recommended reviewers. For further details about the Review of Financial Markets and how to submit articles, see cisi.org/academic

HAVE YOUR SAY

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