Misys FusionRisk

Market commentary

Expected shortfall's redeeming impact

Despite continuing to insist that the move from VaR to Expected Shortfall is wrongheaded and potentially dangerous, David Rowe argues that the shift may have a one important redeeming impact.

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As is well known, the Basel Committee on Banking Supervision is insisting on the use of expected shortfall rather than value-at-risk in the calculation of regulatory market risk capital requirements. Despite continuing to insist this change is wrongheaded and potentially dangerous, David Rowe argues that the shift may have a one important redeeming impact.

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The Problems with Expected Shortfall

Readers of my monthly Risk magazine column will not be surprised that I consider the shift from value-at-risk (VaR) to expected shortfall in the revised Basel Capital Accord to be at best useless and at worst positively dangerous. In my view, the motivation for the change was for regulators to give the false impression that they were doing something about what we have come to call Black Swans. Uninformed politicians and the general public would easily be duped into thinking that "incorporating assessment of the complete tail of simulated loss distributions" would substantially reduce the future likelihood of major systemic events like the collapse of the subprime mortgage market.

This viewpoint smacks of what Jacques Barzun called scientism, "the fallacy of believing that the method of science must be used on all forms of experience and, given time, will settle every issue". Although statistically based distributional methods failed to warn of the last crisis, those in thrall to scientism believe that a little tinkering with their methods will correct the problem. In truth, analysis of Black Swans requires structural analysis and seasoned judgment rather than more complicated statistical calculations on the same types of data we have utilized all along. Shifting to expected shortfall is dangerous in that it is likely to recreate the same groundless belief among the technically uninitiated that once surrounded VaR, namely that it represents some kind of "worst case loss".[1]

As should be evident by now, my thunderous sermonizing against expected shortfall has left me feeling like a voice crying in the wilderness. The Basel Committee and regulators around the world felt irresistible political pressure to do something and replacing VaR with expected shortfall was the type of naïvely plausible step that would help quiet the critics.

That leaves bankers and system vendors in the situation so well captured by the immortal words of Alfred, Lord Tennyson in The Charge of the Light Brigade:

Theirs not to make reply,
Theirs not to reason why,
Theirs but to do and die

Well OK, that is rather over-dramatising the current situation. The stakes are not life and death. The banking industry is only being asked to spend billions of dollars on a highly questionable form of analysis that may well mislead many into a false sense of complacency. At this point it is true, however, that ours is "not to reason why". Banks and system vendors simply need to get on with the necessary steps to achieve compliance. Despite the frustration of this position, it does prompt an important question. Can our efforts to meet this regulatory requirement yield some significant advantages beyond being allowed to continue in business?

On this score I believe the answer is yes, but understanding why requires some understanding of the details of how expected shortfall is to be calculated as well as the mandated operational requirements.

"Theirs not to make reply,
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Theirs but to do and die."

Calculating Expected Shortfall with Differential Liquidity under Basel III

When expected shortfall (ES) was first proposed as a replacement for value-at-risk as the central market risk measure in Basel III, it raised serious questions about the computing practicalities involved. This question was compounded by the further introduction of differential liquidity horizons for different risk factors.

Annex 1 of the July 2015 Basel publication Instructions: Impact study on the proposed frameworks for market risk and CVA risk greatly clarifies the current requirements. The resulting calculations imply a significant increase in required computing power for most banks, but the task now looks far more tractable than it once did. The following is a summary of my understanding of the state of play at this point.

1 For more detailed analysis of my criticism of expected shortfall see; Rowe, D. Beyond Distributional Analysis, Risk magazine; July 2010 (http://www.dmrra.com/publications/Risk%20Magazine/201007%20Beyond%20Distributional%20Analysis.pdf) and Rowe, D.; The False Promise of Expected Shortfall; Risk magazine; November 2012 (http://www.dmrra.com/publications/Risk%20Magazine/201211%20The%20False%20Promise%20of%20Expected%20Shortfall.pdf)

The core requirements for deriving Basel III expected shortfall (ES) estimates involve:

- trade level simulations
- with full valuation methods [2]
- based on shocks to risk factors
- that are calibrated to 10-day changes
- during an appropriate stress period
- applied instantaneously.

One difficulty this combination of requirements poses is that some current types of trades may be so new that data to value them did not exist in a chosen period of historical stress.[3] To address this problem, the Basel ES methodology begins with calculation of ES based on a set of shocks for the Full set of risk factors calibrated to the Current (most recent 12-month) period.

This is designated as $ES_{F,C}$. Once this value is derived, there is a prescribed method to convert it to ES during the chosen period of stress. What follows will first describe the process for calculating $ES_{F,C}$ followed by the process to convert the result to one reflecting the historical stress period.

"One difficulty this combination of requirements poses is that some current types of trades may be so new that data to value them did not exist in a chosen period of historical stress."

The Mechanics for Calculating the Basel III Current Expected Shortfall ($ES_{F,C}$)
Assume we have K sets of simulated 10-day shocks for all risk factors calibrated to the most recent 12 months. The calibration could be based on parametric Monte Carlo scenario generation or some variant of historical simulation.

Designate the change in value of

- trade i
- relevant to liquidity horizon j in
- simulation k

as ΔV(i,j,k).

Start with a 10-day horizon, designated as liquidity horizon 1 by Basel, and apply full valuation to all trades using the 10-day shocked values of the relevant risk factors. Summing these simulated trade values across all trades yields a set of K simulated portfolio P&L values ΔV(•,1,k) for simulation 1 to simulation K. Averaging the 2.5% largest losses yields the 10-day expected shortfall.

The next step involves the treatment of extended horizons for risk factors considered less than completely liquid. Under the Fundamental Review of the Trading Book, risk factors are allocated into five liquidity buckets each with its own specified minimum liquidity horizon.

The designated indices for each bucket (j) and their liquidity horizons are:

j	LH_j
1	10 days
2	20 days
3	60 days
4	120 days
5	250 days

2 The instructions do indicate that, "For full-revaluation ES, approaches that capture curvature risk such as grid-based methods would be appropriate." Instructions: Impact study on the proposed frameworks for market risk and CVA risk; Annex 1 Proposed market risk framework (July 2015) p.91.

3 Probably the most obvious fairly recent example of this was the introduction of the euro as a distinct currency in 1999. One might have chosen to take a weighted average of the historical values of the constituent currencies, but these individual currency markets had their own dynamics that did not necessarily reflect how the combined currency would respond to various events.

A given trade's value may be determined by multiple risk factors with different liquidity horizons. Assuming for the moment that a trade matures at a point beyond the longest liquidity horizon of its underlying risk factors, then for each of the relevant liquidity horizons j>1, it is necessary to calculate the value of the trade based on 10-day shocks to only those risk factors with liquidity horizons LH_j or longer, holding risk factors with shorter liquidity horizons constant. Summing across all trades for a given liquidity horizon j results in a set of K simulated portfolio P&L values ΔV(•,j,k) for simulation 1 to simulation K. These changes in value are used to derive a 10-day expected shortfall driven by only the changes in the risk factors with liquidity horizons LH_j or longer.

Call the result:

$ES_{j,10\text{-}day}$ or ES(j,1)

This is scaled to an expected shortfall estimate at the liquidity horizon LH_j by multiplying by the square root of time. Thus:

$ES(j,j) = ES_{j,10\text{-}day} \bullet \text{sqrt}(LH_j / 10)$

While not stated explicitly, presumably the ES impact of any trade is set to zero for a liquidity horizon beyond its maturity date.

Thus, in addition to the full valuations for every trade using 10-day shocks applied to all risk factors, a trade may also need to be valued as many as four additional times based on the 10-day shocks to four different subset of its risk factors relative to liquidity horizons 2 to 5. A valuation is required relative to trade i and liquidity horizon j, provided:

- the trade maturity date is greater than LH_j and
- one or more of the risk factors affecting the value of the trade has a liquidity horizon greater than or equal to LH_j.

Note that these full valuations are all based on 10-day shocks to the relevant risk factors, meaning that one set of shocked risk factors can be created, stored and reused as required.

Define the set of risk factors affecting a given trade i with liquidity horizons $\geq LH_j$ as Q(i,j). For a given trade, if Q(i,j) = Q(i,j-1), then it is not necessary to value the trade for liquidity horizon j since, for any given simulation k, V(i,j,k) = V(i,j-1,k). The difference will be that the 10-day ES to which V(i,j,k) contributes will be scaled up by a larger multiplier than the ES to which V(i,j-1,k) contributes.

As is often the case, a specific example may be useful. Consider a trade i determined by two risk factors, one with a liquidity horizon of 20 days (j=2) and one with a liquidity horizon of 120 days (j=4). Further assume that the trade matures in 130 days. The required full valuations for this trade are all based on 10-day shocks to these two risk factors.

For each simulation k, we need to calculate:

ΔV(i,1,k) based on 10-day shocks to both risk factors.

ΔV(i,2,k) = ΔV(i,1,k) since it is based on the same shocks to both risk factors.

ΔV(i,3,k) is based on full valuation with 10-day shocks to the second risk factor only.

ΔV(i,4,k) = ΔV(i,3,k) since it is based on the same 10-day shock to the less liquid risk factor that was used in the previous step.

ΔV(i,5,k) = 0.0. Since the trade matures before 250 days, it will have zero contribution to the 250-day ES.

Note that if the trade had matured in 80 days, then ΔV(i,4,k) would also have been set to 0.0, since the trade would have matured before 120 days.

These 10-day ES calculations need to be made five times, based respectively on the impact of:

One: All risk factors [$ES_{LH\geq10:10\text{-}day}$ or ES(1,1)] This ES is based on the P&L vector containing K simulated changes in value ΔV(•,1,k) created by summing all values of ΔV(i,1,k) over trade index i.

Two: All risk factors with minimum liquidity horizons ≥ 20-days [$ES_{LH\geq20:10\text{-}day}$ or ES(2,1)] This ES is based on the P&L vector designated by ΔV(•,2,k)

Three: All risk factors with minimum liquidity horizons ≥ 60-days [$ES_{LH\geq60:10\text{-}day}$ or ES(3,1)] This ES is based on the P&L vector designated by ΔV(•,3,k)

Four: All risk factors with minimum liquidity horizons ≥ 120-days [$ES_{LH\geq120:10\text{-}day}$ or ES(4,1)] This ES is based on the P&L vector designated by ΔV(•,4,k)

Five: All risk factors with minimum liquidity horizons ≥ 250-days [$ES_{LH\geq250:10\text{-}day}$ or ES(5,1)] This ES is based on the P&L vector designated by ΔV(•,5,k)

"Can our efforts to meet this regulatory requirement yield some significant advantages beyond being allowed to continue in business?"

Note that all these calculations are for a 10-day horizon with the more liquid risk factors sequentially eliminated from the successive calculations. This means that, with all the 10-day value change results for every trade i at every liquidity horizon j and every simulation index k, it is possible to calculate all the ES values from these detailed results, in total and by trading desk.

It is only necessary to:

- filter the relevant trades to be processed,
- summing across trades yields P&L values ΔV(•,j,k) for each liquidity horizon j and simulation index k, and
- then average the largest 2.50% of the losses for each liquidity horizon j.

These 10-day ES values are converted to 20-day, 60-day, 120-day and 250-day changes using the square root of time rule. Thus:

One: $ES_{LH\geq10:10\text{-}day} = ES_{LH\geq10:10\text{-}day}$ * sqrt(10/10) = $ES_{LH\geq10:10\text{-}day}$ = ES(1,1)

Two: $ES_{LH\geq20:20\text{-}day} = ES_{LH\geq20:10\text{-}day}$ * sqrt(20/10) = $ES_{LH\geq20:10\text{-}day}$ * sqrt(2) = ES(2,2)

Three: $ES_{LH\geq60:60\text{-}day} = ES_{LH\geq60:10\text{-}day}$ * sqrt(60/10) = $ES_{LH\geq60:10\text{-}day}$ * sqrt(6) = ES(3,3)

Four: $ES_{LH\geq120:120\text{-}day} = ES_{LH\geq120:10\text{-}day}$ * sqrt(120/10) = $ES_{LH\geq120:10\text{-}day}$ * sqrt(12) = ES(4,4)

Five: $ES_{LH\geq250:250\text{-}day} = ES_{LH\geq250:10\text{-}day}$ * sqrt(250/10) = $ES_{LH\geq250:10\text{-}day}$ * sqrt(25) = ES(5,5)

These five values are aggregated using a weighted root mean sum of squares calculation with weights based on the incremental time period for which they apply. Thus,

$$ES_{F,C} = \text{sqrt}\{ ES(1,1)\text{^}2 + \sum_{J=2}^{5} [ES(j,j) * \text{sqrt}[(LH_j - LH_j\text{-}1)/10]]\text{^}2 \}$$

Fulfilling the Requirement for ES to Reflect a "Historical Period of Stress"

The calculation thus far is based on a recent historical period for which virtually all risk factors will have historical data to use in the calibration.[4] As noted earlier, however, Basel requires that the final ES used to determine the regulatory capital requirement be calibrated to a relevant historical stress period.

This requires a way to overcome the problem of data limitations. Some current trades often depend on factors with insufficient history to evaluate their behaviour during the relevant stress period.

4 There is allowance for a fairly punitive capital charge applied to trades with non-modellable risk factors, as when a risk factor lacks a full year of history for use in calibrating current period shocks.

The approach to this mandated by Basel involves identifying a historical period of stress and calculating the expected shortfall for the current portfolio using a Reduced set of risk factors for both the historical Stress period ($ES_{R,S}$) and the Current calibration period ($ES_{R,C}$).

The final expected shortfall used in the capital calculation is then derived by scaling $ES_{R,S}$ up to the extent that current ES with the full set of risk factors ($ES_{F,C}$) exceeds current ES with the restricted set of risk factors ($ES_{R,C}$).

Thus,

$ES = ES_{R,S} \bullet \max(ES_{F,C} / ES_{R,C}, 1.0)$

This presents two additional challenges. First it is necessary to select the period of maximum stress relative to the current portfolio. Once this period is established, it is necessary to calculate ES two more times based on the restricted set of risk factors with perturbations calibrated to the stress period and the current period respectively.

“With all the 10-day value change results for every trade at every liquidity horizon and every simulation index, it is possible to calculate all the ES values from these detailed results, in total and by trading desk.”

Selecting the Historical Period of Maximum Stress
As stated in the Proposed market risk framework (July 2015) document (p. 92)

- “For measures based on current observations ($ES_{F,C}$), banks must update their data sets no less frequently than once every month and should also reassess them whenever market prices are subject to material changes. This updating process must be flexible enough to allow for more frequent updates. The supervisory authority may also require a bank to calculate its Expected Shortfall using a shorter observation period if, in the supervisor’s judgement; this is justified by a significant upsurge in price volatility. In this case, however, the period should be no shorter than [6] months.”
- “For measures based on stressed observations ($ES_{R,S}$), banks must identify the 12-month period of stress over the observation horizon in which the portfolio experiences the largest loss. The observation horizon for determining the most stressful 12 months must, at a minimum, span back to 2005. Observations within this period must be equally weighted. Banks must update their 12-month stressed periods no less than monthly, or whenever there are material changes in the risk factors in the portfolio.”

Presumably the first bullet point also applies to $ES_{R,C}$, although lack of its mention may imply that the perturbations of the restricted risk factor set used in the full risk factor evaluations can simply be applied with no change in the risk factors not included in the restricted set.

Updating the current risk factor perturbations monthly would require that this process be thoroughly automated. Nevertheless, it should not present a serious difficulty for most institutions. Meeting the requirements of the second bullet point could be more daunting.

An extreme view would be that it is necessary to evaluate ES for the current portfolio for the restricted set of risk factors calibrated to every rolling one-year period in the extended historical data sample, moving the one year sample in increments of one day! Surely this will not be required, but some clarification of how thorough a search process will be expected has yet to be articulated formally.

Calculating ES with the Restricted Risk Factor Set

There is no need to repeat the full details described above for the calculation of $ES_{R,S}$. Suffice it to say that this process needs to be repeated in every detail for the set of perturbed values of the restricted risk factor set based on the chosen period of historical stress. The process also could be repeated using perturbations of the restricted risk factor set based on the current period. It may, however, be permissible to use the perturbations of the restricted risk factors that are contained in the current period calibration of the full risk factor set. If so, it will be possible to reuse the detailed valuations from the calculation of $ES_{F,C}$ for any trades that are only affected by the restricted risk factors.

Procedural Requirements

Focusing on the details of complex calculations can make it easy to overlook the implications of mandated procedural requirements. As usual, however, these have significant implications for how to design the necessary information system architecture. Relevant requirements related to expected shortfall estimation (including ones implied by the above discussion) include:

- Reconciliation of results from the individual trades, to trading desk aggregates and all the way up to the entire enterprise
- Demonstrated consistency between risk results and trading desk P&L reports
- Treatment of differential liquidity horizons for different risk factors
- Regular (at least monthly) updates of the relevant historical stress period
- Regular (at least monthly) recalibration of risk factor perturbations for both the current historical period and the historical stress period
- Storage and flexible aggregation of a massive volume of simulation detail

Calculation of regulatory expected shortfall will be a computationally daunting task. Nevertheless, recent clarifications mean this will be less onerous than some have feared. It now is possible for banks to move ahead with designs for their systems.

So Where is the Redeeming Impact?

Unfortunately, there is a significant chance that this whole effort will prove to be nothing more than a very costly compliance exercise. Insofar as there may be ancillary benefits, I think they will flow from meeting the above procedural requirements.

The requirements to perform trade-level valuations and to reconcile results all up and down the organisation are likely to have profound implications. The ideal approach to meeting these requirements is deployment of a centralized, highly flexible and massively parallelized valuation engine accessible to both trading and risk applications. This would guarantee consistency between accounting and risk systems and between desk-level and enterprise risk results.

Any other approach is bound to degenerate into a massively expensive and ultimately futile process of continuous reconciliation. Achieving this type of broad accessibility is not plausible using legacy system architecture with heavily coupled logical components.

Only a modern highly decoupled architecture that allows incremental enhancements with little or no risk of disruption to existing processes will work.

Calculating ES is so massive an exercise, and the demands for demonstrable results reconciliation and auditability are so daunting, that a closed system in which most intermediate results are processed and then discarded simply will not fly. A facility to store a massive volume of simulation results by trade, liquidity horizon and scenario is essential. It is also important that this facility can filter, aggregate and otherwise process this mass of results efficiently. This is the only plausible way to maintain intraday updates without reverting to crude and inaccurate shortcuts that make risk numbers less and less trustworthy as the trading day progresses.

Perhaps most importantly, it is almost inconceivable that dedicated hardware for this process alone makes commercial sense. The leverage that massive parallelisation brings to the process can only be fully exploited in a cloud environment. This can be an internal cloud, but many of the necessary calculations can be anonymised and distributed across an external cloud with no serious information security risk.

With the right system architecture that takes its cue from Web applications, ES calculations could be updated incrementally throughout the trading day based on prior day closing prices. Except on days of massive market disruption, such intermediate updates that fully reflect portfolio changes will be quite accurate indicators of close of business results.

Once established, such a simulation and results storage system could supply answers to more specific questions relevant to risk managers. In particular, it would permit investigation of results in the tail of the distribution for any segment of the organisation, right down to which trades contributed the largest losses. With a well-designed scenario generator, it also would be ideal for performing stress analysis grounded in full trade-level valuations.

In brief, a well-designed system to perform the calculations required to produce mandated expected shortfall results could serve many other valuable purposes. Among other things, it could be the catalyst for banks to begin an urgent transition to 21st Century information system architecture. It could centralise pricing in one place for all accounting, trading and risk management functions. It could introduce agility and flexibility that are unthinkable in legacy system architecture.

The surest sign of the success of a bank's Basel III market risk efforts would be to discover that satisfying regulatory requirements is the least of its many contributions.

Summary

Misys FusionRisk can provide a cost-effective means to meet the demands of the Fundamental Review of the Trading Book and generate valuable information to improve both tactical and strategic trading and risk decisions.

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About Misys

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