



Field Guide to Internal Models under the Basel Committee's – “Fundamental review of the trading book” framework

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ABSTRACT

This article provides an overview of the key aspects of how the BIS consultative document “Fundamental review of the trading book: A revised market risk framework” affects internal models. In particular it looks at how an existing Basel 2.5 compliant Risk Engine can be converted to comply with FRTB. Points of contention and vagaries in the FRTB paper are also highlighted.

1. Introduction

The 2008 financial crisis caught the regulators in Europe and the US by complete surprise. The resulting domino effect of failing financial institutions was only halted by a massive bailout by the world's governments. These banks had to be bailed out because they were “too big to fail” (Storkin, 2010). As a result of this a raft of new legislation was introduced to prevent it happening again. The Dodd-Frank act aimed to prevent banks becoming “too big to fail” and to increase transparency by moving more derivative products from OTC to exchange traded (SEC, 2010). The FRTB paper: “Fundamental review of the trading book: A revised market risk framework” (FRTB) is designed to make financial institutions hold more accurate (larger) levels of risk capital to compensate for these “extreme” events (BIS, 2013). This paper provides an overview of the key points for in-house models.

2. The Treatment of Credit

2.1 Securitised products

Securitisation is the process whereby a portfolio of underlying assets are pooled so they can be repackaged into interest-bearing securities (Jobst, 2008). An example of this would be the infamous Mortgage-backed Security (MBS) that was a major factor in the crisis of 2008. The FRTB paper states that these products cannot use internal models and must be reported under the Standard Approach. The Standard Approach is covered in section 5 of this paper.

2.2 Non-Securitised products

From the FRTB paper “*the Committee has agreed that non-securitisation credit positions in the trading book will be subject to a separate Incremental Default Risk (IDR) charge*” What this means is that when calculating market risk for a portfolio: any net credit positions are hit with

an extra charge. So how do you calculate this charge? The FRTB paper is fairly vague on this point. It states that banks must use a two-factor simulation model with default correlations based on equity prices. The European Banking Federation points out that the use of equity data does not necessarily give an indication of default correlations and cannot be used to calibrate sovereigns' correlations (EBF, 2014).

3. Market Risk Measurement

3.1 Move from VaR to Expected Shortfall

One of the new requirements of the FRTB is to move from VaR to Expected Shortfall (ES). For clarity I will give a brief illustration of what the measures actually mean. Take a portfolio and calculate a set of potential returns that we can receive from holding it one day into the future. Then arrange these potential returns in order from lowest value (worst loss) to highest value (best profit). For a 95th percentile VaR or ES we then consider the subset of the lowest 5% of these returns. The VaR is the largest value in this subset of smallest values. The Expected shortfall is the expected value (average) of the returns in this subset.

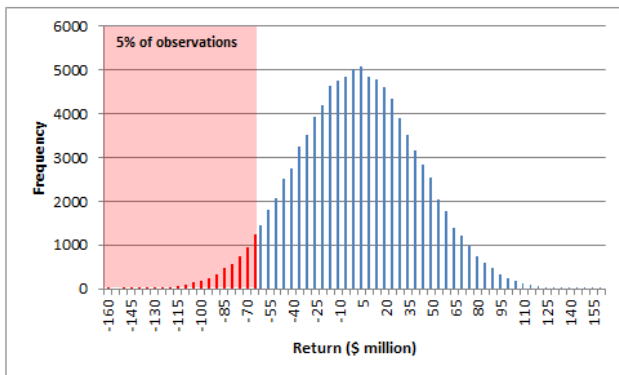


Fig1. Distributions of Daily Returns

ES has the benefit that it is a coherent risk measure whereas VaR is not. A coherent risk measure has a number of properties but the important one that VaR fails on is the subadditivity property. If you consider two portfolios 'a' and 'b' then for subadditivity (Jorion, 2007):

$$Risk(a + b) \leq Risk(a) + Risk(b)$$

Why is subadditivity important? The cornerstone of modern portfolio theory is that a diversified portfolio has less risk than a non-diversified one (Markowitz, 1952). With VaR this criterion does not necessarily hold true. However in section 3.5 we see that the BIS paper has its own ideas about diversification.

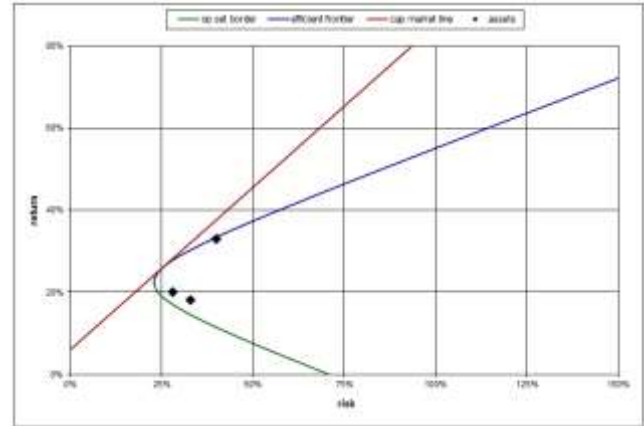


Fig 2. The efficient frontier

From a practical standpoint, is the computation of ES going to be more difficult than computing VaR? Well, in its current form the FRTB paper (BIS, 2013) specifies that the model must be ES but makes no specification as to the underlying model distribution assumptions. Say for example, you have an existing VaR engine that must be converted to ES. With a Historical Simulation (HS) approach you use real historical returns of the past underlying risk factors to simulate the future returns of the portfolio. This approach makes no distributional assumptions and in fact the real historical distributions are embedded in the simulations. So the calculation of expected shortfall is not more computationally intensive. With a full revaluation Monte Carlo simulation the FRTB paper is less clear. If one is allowed to use the distributional assumptions of the main simulator (usually multivariate Gaussian) then this becomes like the historical simulation conversion exercise and is not more computationally intensive. However if the FRTB paper really demands a separate model for the tail risk then this is much more computationally intensive (Yamai, 2002), (Nadara, 1997).

It is not clear in the FRTB paper if a full revaluation is required for all instruments in the ES model or if approximations (like delta-gamma) are allowed. For institutions that rely on approximation methods then the move to full revaluation could be a heavy burden.

The other point of note in the FRTB paper is that a 97.5% ES will be used instead of a 99% VaR. The idea is that the final numbers will be broadly similar but that the ES will be less prone to jumps in daily risk.

3.2 Stressed Calibration

As mentioned in the previous section the basic calculation of ES is not more computationally intensive than VaR. but the FRTB paper mentions that this ES "must be calibrated to stressed conditions" (BIS, 2013). Under Basel 2.5 the idea was to produce both a normal VaR and a stressed

VaR for reporting purposes. The FRTB paper seeks to combine these two risk measures into one ES measure. For historical simulation the stressed ES could be produced by taking the current portfolio and running it over the series of historical risk factors that were present in an extreme stress scenario e.g. 2008/2009. For Monte Carlo methods a similar technique could be applied.

What if some of the risk factors are new and not present in the historical stress dataset? The BIS has proposed the following formula:

$$ES = ES_{R,S} \frac{ES_{F,C}}{ES_{R,C}}$$

Where:

$ES_{R,S}$ = Expected Shortfall of the current portfolio calibrated on the stress period and reduced risk factors.

$ES_{F,C}$ = Expected Shortfall of the current portfolio calibrated on the recent history and full risk factors.

$ES_{R,C}$ = Expected Shortfall of the current portfolio calibrated on the recent history and reduced risk factors.

As well as being much more computationally intensive (3 ES calculations) this combined ES model has a number of problems. The daily ES numbers produced will be significantly higher than the unstressed VaR. For the purposes of setting in-house trading limits a risk department may choose to keep unstressed VaR or unstressed ES. This creates an additional computational burden on the risk engine and also disconnects the regulatory reporting from the in-house risk reporting function.

The FRTB paper specifies that the stress period for calibration must be a 12 month period going back at least as far as 2005. This may be a considerable problem for institutions that have insufficient market data.

3.3 Reporting Granularity

The model approval process requires reporting down to the trading desk level. The rationale behind this is that if a desk level model fails approval then it does not impact the entire bank.

3.4 Market Illiquidity

In the 2008 crisis one of the main characteristics was a sudden and severe impairment of market liquidity. The existing VaR models failed to anticipate this, so the BIS committee decided to incorporate a measure for market liquidity in the market risk model requirements. They propose to do this by computing the ES for differing time horizons for different asset classes (see appendix B).

The European Banking Federation have a number of criticisms of this approach. While broadly accepting of a liquidity risk adjustment they question the arbitrary time horizons and note that some risk factors like forex and interest rates actually overlap. The other point of note is that the use of differing time horizons across risk factors will break the link between the capital charge and the way risks are managed at the desk level.

So how would this be achieved with a banks existing risk engine? With historical simulation the proper treatment of multi day time horizons requires a large dataset of non-overlapping returns. The BIS paper mentions this and acknowledges the huge additional data burden. As a way of a compromise it approved the use of overlapping returns. This method is known to be problematic and underestimates the risk (Sun et al, 2009). With a full revaluation Monte Carlo framework then extending a day-ahead VaR model out multiple days is a lot more computationally intensive if all days must be simulated. For Monte Carlo it is not clear in the BIS paper if a simple square root of time scaling factor can be applied to the risk factors or if full multi day simulation is required.

3.5 Hedging

As mentioned in section 3.1 a diversified portfolio is inherently less risky. However the devil is in the details and due to the nature of correlation. Correlation is a measure of the mutual connection between assets. If we have two assets and can sample the time series of price fluctuations over a period then the cross co-variance is:

$$E[(X_t - \mu_x)(Y_t - \mu_y)]$$

Let's consider the following example. One has exposures in two assets with a cross correlation of 1 but with opposite positions then theoretically you can offset the total exposure by netting the two. The flaw in this assumption is that the past price co-movements will hold into the future. In the 2008 financial crisis correlation broke down and the real hedging effect was much less than the models predicted. Because of this the BIS paper has proposed to curb the diversification effect by specifying that the firm-wide ES measure must be the sum of the trading desk level ES measures. In addition to this, cross correlations are to be calculated on the 12 month period of extreme stress at the desk level.

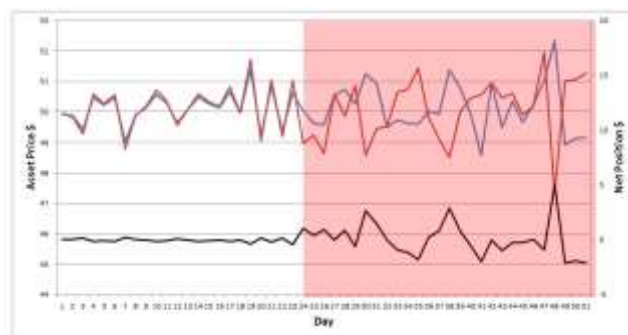


Fig 3. The effect of a correlation breakdown on a hedged position

4. Model Approval Process

4.1 Overview

To get an internal model approved a number of steps must be passed (see Appendix A). Internal models are approved at the trading desk level. Once a trading desk has been deemed “in scope” then a set of three tests are applied: P&L Attribution, Backtesting, and the model-independent assessment.

4.2 P&L Attribution

If you take the price of a derivative today then the theoretical change in price can be calculated by a Taylor Series Expansion of the underlying risk factors. If we consider a simple derivative with sensitivities to: one underlying stock, interest rates, and volatility, then the change of value of the portfolio can be approximated by:

$$\Delta\pi = \frac{\partial\pi}{\partial S}\Delta S + \frac{1}{2}\frac{\partial^2\pi}{\partial S^2}(\Delta S)^2 + \frac{\partial\pi}{\partial r}\Delta r + \frac{\partial\pi}{\partial\sigma}\Delta\sigma + \dots$$

Where

π is the price of the derivative

S is the underlying stock price

r is the interest rate

σ is the implied volatility

So if we know the change in the risk factors from today to tomorrow then we can calculate a theoretical P&L that apportions the price move to the various risk factors. This theoretical P&L can be then compared to the real P&L and used as a way to test that risk model is using the correct set of risk factors. This technique can be scaled up to the portfolio level and is known as the sensitivities method. The BIS paper requires that these P&L differences (theoretical – actual) are recorded daily and over an appropriate period the following two metrics are produced:

- The mean of the difference between the theoretical and actual P&L (i.e. the “unexplained P&L”)
- The variance of the unexplained P&L divided by the variance of the actual P&L

4.3 Backtesting

The BIS paper demands that the risk engine is backtested against at least a year’s worth of data and using the 97.5% and 99% VaR measure (not ES). What this means is the daily VaR figures are computed over the backtesting period and compared to real P&L moves (excluding new trades).

While reasonable in principle the BIS paper has included a 3 zones system to accept or reject risk models based on back testing evidence. Based on a sample of 250 observations and a 99% VaR you would expect the VaR to be exceeded ~2.5 times. For a real backtesting score of anything up to 4

breaches then the BIS paper classifies this is “green” and the model is deemed accurate. For breaches going into the yellow zone and red zones penalties are applied to the overall model accuracy score. See Appendix C for details.

The European Banking Federation notes that using VaR to backtest ES is a rather weak test. Therefore it would not make much sense to automatically reject a model solely based on backtesting results. In fact this method of backtesting also fails to consider the magnitude of the exceedance. You could have a model that falls into the “yellow zone” but where some of the breaches are tiny. Alternative backtesting methods have been known about for some time (Haas, 2001).

4.4 Model-independent assessment tool

In a nutshell the model independent assessment tool is a test of the following form:

$$\frac{\text{Capital}}{\text{Exposure Measure}} < \text{Threshold}$$

Where:

Capital – is the risk capital calculated for the portfolio by the internal model

Exposure Measure – is the exposure of the internal model

Threshold – is a BIS calculated value

What this means is that if the ratio of internal model capital to exposure falls below a certain threshold then the internal model is rejected. There is no information on how these thresholds are calculated. The BIS paper refers to the Exposure Measure mentioned as possibly being based on the Basel 3 leverage ratio. A more detailed explanation of this is found in (BIS 2, 2014). With Basel3 the Threshold was set at 3%.

5. Relationship between Internal Models and the Standardised Approach

If an internal model fails to be accepted then a bank must calculate their risk capital using the much more onerous Standardised Approach. The Standardised Approach is now quite complex and a detailed explanation is covered in the BIS paper. Basically it is an alternative way to compute a risk capital measure from a portfolio. Firstly all trades are decomposed into “notional positions” and then bucketed into risk factors for each asset class. Predetermined weights are assigned to each bucket and then a formula is used to calculate the overall risk. This formula uses preset correlation values for correlations between notional positions in the same bucket.

From a model development perspective implementing the Standardised Approach could take a long time and if a bank fails an internal model then not only are they hit with a jump in risk capital but also a large development cost. It is not clear if the BIS committee will allow multiple

tries to get an internal model approved or whether one failure means an automatic move to the Standardised Approach.

6. Conclusion

This FRTB paper aims to make a bank's day-to-day trading activities less risky by forcing a framework that increases the risk capital charge. However there are a number of points that need clarification. From a bank's perspective it is far more preferable to have an internal model approved that have to use the Standard Approach. But we have seen valid internal models could fail because of flaws in the approval process. If this happens then one can foresee a situation where a low risk trading desk is heavily penalised with a large risk capital charge.

Appendix A. FRTB Model Approval Process

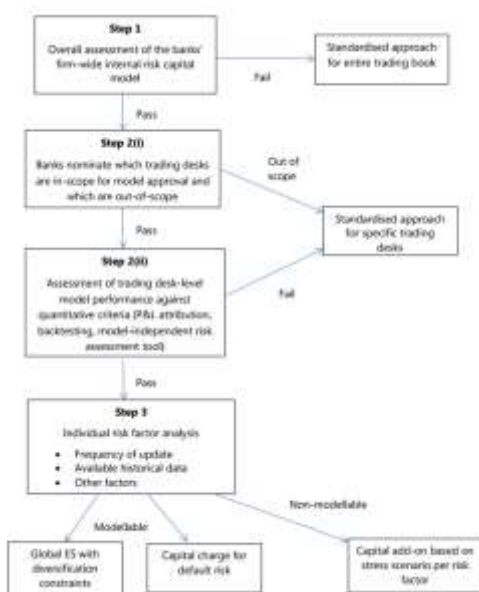


Fig 3.0 The Model Approval Process Workflow - sourced from (BIS, 2013)

Appendix B. Liquidity Time Horizons

Risk Factor Category	Days
Interest rate X	20
Interest rate ATM volatility X	60
Interest rate (other) X	60
Credit spread – sovereign (IG) X	20
Credit spread – sovereign (HY) X	60
Credit spread – corporate (IG) X	60

Credit spread – corporate (HY) X	120
Credit spread – structured (cash and CDS) X	250
Credit (other) X	250
Equity price (large cap) X	10
Equity price (small cap) X	20
Equity price (large cap) ATM volatility X	20
Equity price (small cap) ATM volatility X	120
Equity (other) X	120
FX rate X	20
FX ATM volatility X	60
FX (other) X	60
Energy price X	20
Precious metal price X	20
Other commodities price X	60
Energy price ATM volatility X	60
Precious metal price ATM volatility X	60
Other commodities price ATM volatility	120
Commodity (other)	120

Fig 4.0 The proposed liquidity time horizons - sourced from (BIS, 2013)

Appendix C. Back Testing Traffic Lights

Zone	Number of exceptions	Increase in scaling factor	Cumulative probability
Green zone	0	0.00	8.11%
	1	0.00	28.58%
	2	0.00	54.32%
	3	0.00	75.81%
	4	0.00	89.22%
Yellow zone	5	0.40	95.88%
	6	0.50	98.63%
	7	0.65	99.60%
	8	0.75	99.89%
	9	0.85	99.97%
Red zone	10 or more	1.00	99.99%

Fig 5.0 The proposed backtest 3 zones- sourced from (BIS, 2013)

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