Data Considerations for FRTB Success

GoldenSource Solutions FRTB

White Paper

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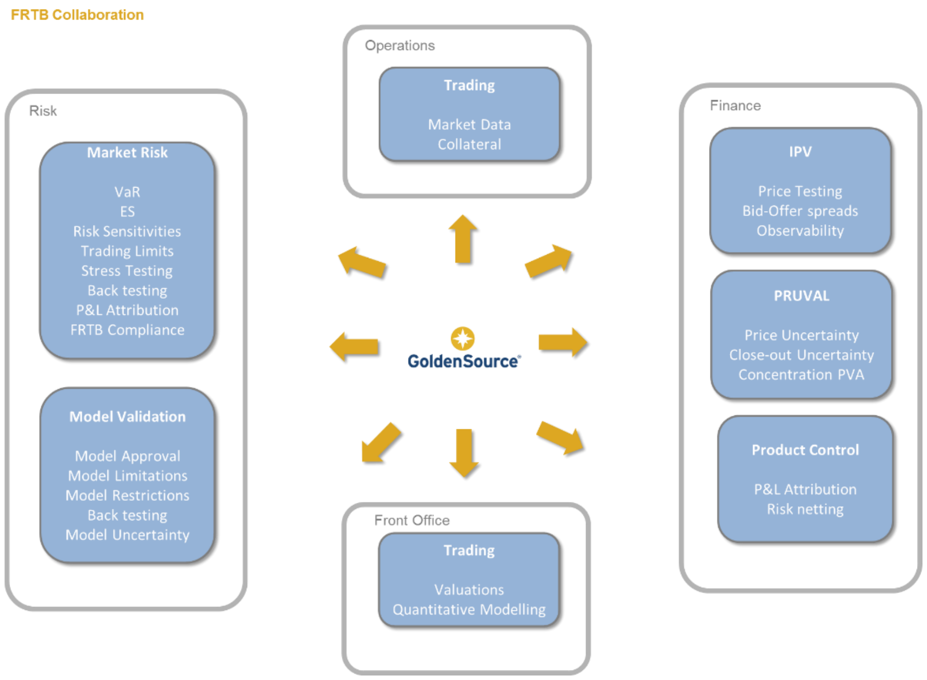
Introduction

Banks need to have sufficient capital set aside to protect against adverse movements in market prices. The Basel Committee on Banking Supervision Standard number 352, referred to in the industry as Fundamental Review of the Trading Book ("FRTB") is a standard ("the Standard") that will empower regulators to ensure that this is the case. While it is a set of rules aimed primarily at Chief Risk Officers tasked with the calculation of regulatory capital for market risk, successful implementations will undoubtedly require collaboration across Finance, Operations and Front Office.



On the face of it, the calculations seem complex. Risk sensitivities, risk weightings, curves, surfaces, Value-at-Risk, Expected Shortfall, liquidity horizons and default probabilities are all involved. However, when looking at the complexity involved in an FRTB implementation, project owners and stakeholders should consider that:

- these calculations are, for the most part, already being done in some guise in most banks
- different banks will generally do these calculations in slightly different ways
- FRTB is a set of rules which prescribe exactly how the calculations should be done

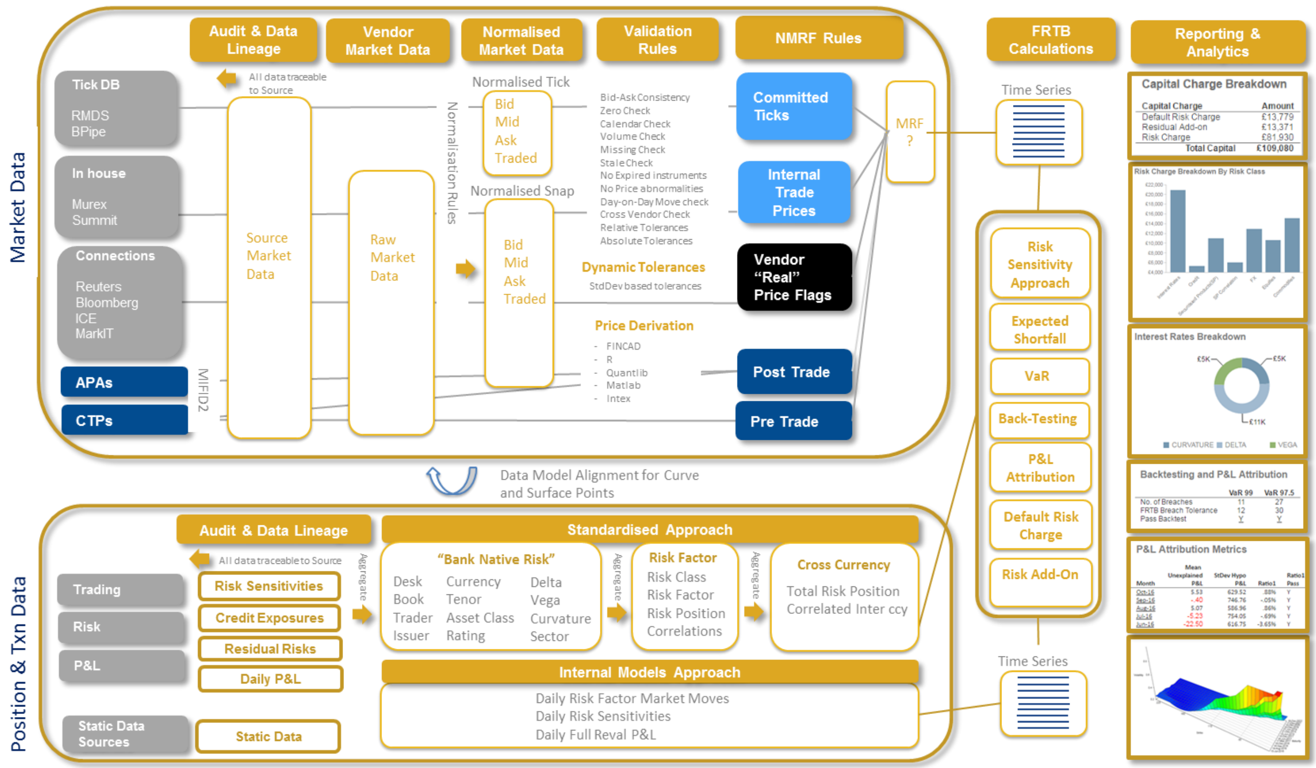
Given these considerations, the most important aspect of a successful FRTB implementation will be the standardisation of the inputs to the calculations. In practice this will require that the inputs (market data, risk data) are fully auditable, traceable and aligned along both time-series and contributor dimensions. While tools (dashboards, statistical calculation routines) for market risk capital calculations will be needed, the true strength of any FRTB capability will be data alignment and auditability. Properly aligned data makes the calculations more transparent and defensible in the face of increasingly onerous audit and regulatory scrutiny.

A Typical FRTB Set of Data Flows

Data inputs into a typical FRTB ecosystem can broadly be broken into two categories

- Market Data
- Position and Transaction Data

Market data is shown in the top section of the diagram below. TPosition and transaction data is shown below Market Data.



An alternative way of viewing these two categories of data is to view them as external versus internal data blocks. Market data can largely be considered external data as it relates to prices of instruments traded outside of the bank and is sourced primarily from external data vendors and exchanges. Position and transaction data, on the other hand, is internal data. It stores information about the banks own trades, risk exposures and P&L.

Market Data

Market data can be introduced to the FRTB ecosystem from a number of different sources:

- Snapped and End-of-Day vendor feeds
- Ticking prices (snapped or filtered)
- Front offices trading systems

With the onset of MIFID2, it is also likely that qualifying price transparency vehicles such as APAs and CTPs will become a source for market data (pre and post trade) in the future.

Clean validated time-series market data is required primarily for the FRTB Internal Models Approach calculations (FRTB-IMA, see below). Tools for choosing the best price (a golden price) for an instrument or a point on a curve each day are critical for success in an FRTB system. The clean, validated daily golden prices (with full lineage to underlying raw market data) become the prices that are each day added to the time series required for FRTB-IMA calculations. Time series prices are required for the following FRTB-IMA calculations:

- P&L Attribution
- VaR back-tests
- Expected Shortfall
- Stressed Expected Shortfall
- Non Modellable Risk Factor determination
- IMA Default Risk Charge

Interestingly, market data is not required for any of the FRTB Standardised Approach (FRTB-SA) calculations. The so called "Risk Charge" (the FRTB SA charge calculated using risk sensitivities) uses risk weights and correlations prescribed by the standard but does not require any market data for its calculations. Similarly the SA "Default Risk Charge" uses default risk weights and hedge benefit ratios prescribed by the standard but, again, does not require any market data for its calculations.

Note that where a bank decides that it wants to trade new products (and those products require new risk factors or instrument market data), it is important that the FRTB system has functionality that will allow the introduction of the associated time series market data. Because the products being traded are new, this time series market data will not be available in Market Risk systems. Typical time-series functionality required when new instruments are traded are

- Time Series Validation (zero checks, null checks, missing data, etc)
- Time Series filling or proxying rules (interpolation, use of basis spreads, cross instrument proxying, etc.

Banks in many cases will have thousands of risk factors and instruments that they require time series data for. FRTB requires that Expected Shortfall calculations uses time series data that goes all the way back to 2007. The ability to store and access such large volumes of data will be critical.

Position and Transaction Data

Position and transaction (P&T) data will be introduced to the FRTB ecosystem from the banks Front Office, Risk and Finance systems. This is internal, proprietary data. Other banks will not and should not be aware of the positions the bank is running. For the purposes of this document, P&T data is generic term that covers the following categories of internal data

- Trade level Risk Sensitivities
- Position level Risk Sensitivities
- Trade level P&L
- Position level P&L

The table below describes for each FRTB calculation, the type of data that the calculation requires

FRTB Calculation	Point in Time P&T Data	Time Series Market Data	Time Series P&T Data
IMA Expected Shortfall	Risk Sensitivity as at valuation date. E.g. position-level IR Vega on the date	Time series market is required to calculate the N-day market moves that are applied	Full revaluation P&L (based on N-day market moves) is required where a full

	that the ES calculation is being run for	to the point-in-time position. E.g. 10-day move in EUR Swaption Vol is derived from time series of daily market data moves	revaluation approach is chosen over a risk sensitivity approach
IMA VaR back-test	Time series risk sensitivities are required to support investigations where VaR back tests fail	Time series market data is required irrespective of whether VaR is calculated using a risk sensitivity approach or a full revaluation approach	Time-series P&L by Risk Factor. The P&L can be calculated on either a risk sensitivity basis or a full revaluation basis Time series risk sensitivities by Risk Factor will be required if the P&L used in the VaR back-test is derived using risk sensitivities
P&L Attribution	Time series risk sensitivities are required to support investigations where P&L Attribution tests fail	Time series market data is required for P&L Attribution to support investigations where P&L Attribution tests fail	Time series “Risk Theoretical P&L” and time series “Hypothetical P&L” are required
Risk Charge	Risk Sensitivity as at valuation date. E.g. risk weights are applied to position-level IR Vega	Not Required	Not Required

Note:

- The assumption in the table above is that risk sensitivities, full revaluation and P&L data will come from the banks upstream Risk, Finance or Front Office systems
- Although the standard does not require it, it is always preferable to take trade-level sensitivities and P&L into the FRTB ecosystem where possible
- The FRTB-IMA P&L Attribution tests are designed to highlight instances where the data used in Risk systems for its calculations, varies significantly from the data used for P&L calculations and reporting

The GoldenSource ‘Curve Shift’ Methodology

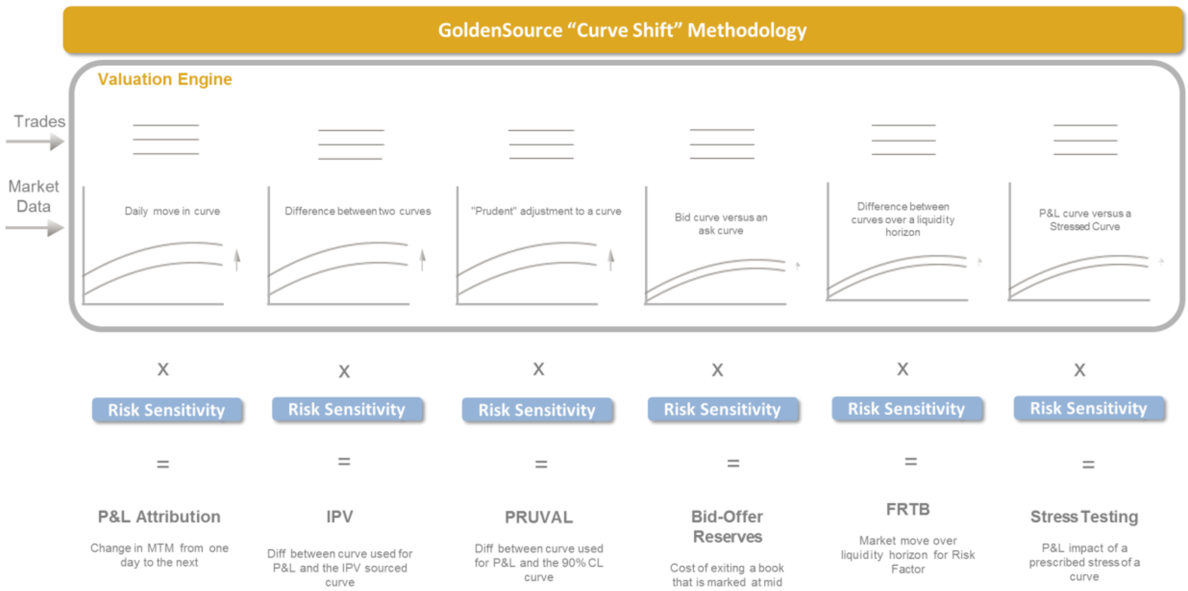
Larger or more complex banks will ideally have a mature data model that has been designed or extended to include all the data types and derivations required for both the Standardised Approach (FRTB-SA) and the Internal Model Approach (FRTB-IMA). Data modelling capabilities will need to enable the capture of real-world risk and market data relationships in a way that minimises the complexity in the calculations required to achieve FRTB compliance. The data modelling will link two sets of data entities:

- Market Data Entities
- Market Risk Data Entities

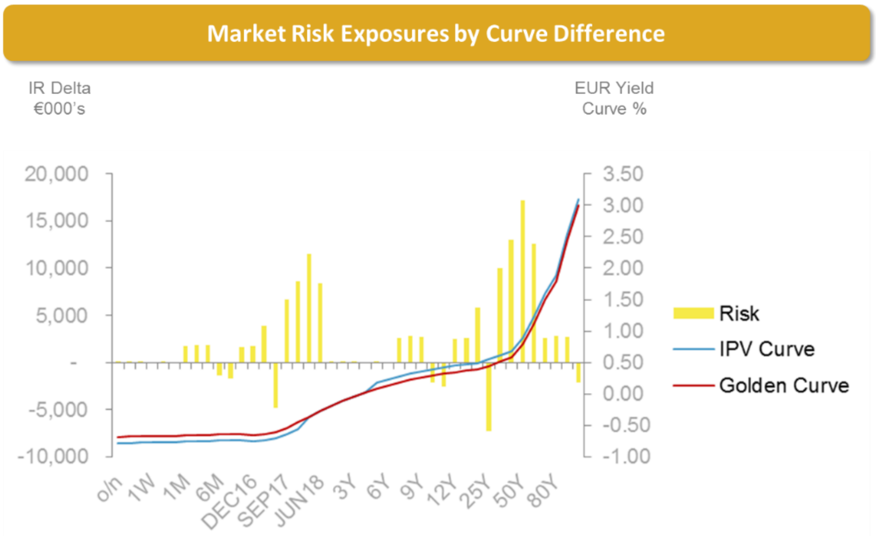
The design of and interplay between these two sets of entities will be the critical determinant of a bank's ability to smoothly manage its FRTB data and feed the calculations efficiently. A concept to achieve this, being proposed by the RiskHub practice at GoldenSource Corporation, is the method of 'Curve Shifts'. Many of the calculations required, not only for FRTB, but also for Risk and Finance requirements, can be done using the Curve Shift methodology. For example,

- P&L Attribution - difference between today's curve and yesterday's curve
- IPV - difference between an IPV curve and a Front Office curve
- PRUVAL - difference between a P&L curve and a Prudent Curve
- Bid-Offer Reserve - difference between a bid curve and an ask curve
- FRTB - market move over liquidity horizon for a risk factor
- Stress testing - P&L impact of a prescribed stress of a curve

The term 'curve' here is used for ease of explanation. The approach applies equally well to surfaces. A volatility surface, for example, can be thought of as a set of curves defined by strike prices of the underlying options. In every instance the approach involves the application of a "shift" in market data to a risk exposure.



The ability to visualise risk sensitivities adjacent to the market data to which they are sensitive will be an essential element of operating with the Curve Shift methodology. See below for an illustration



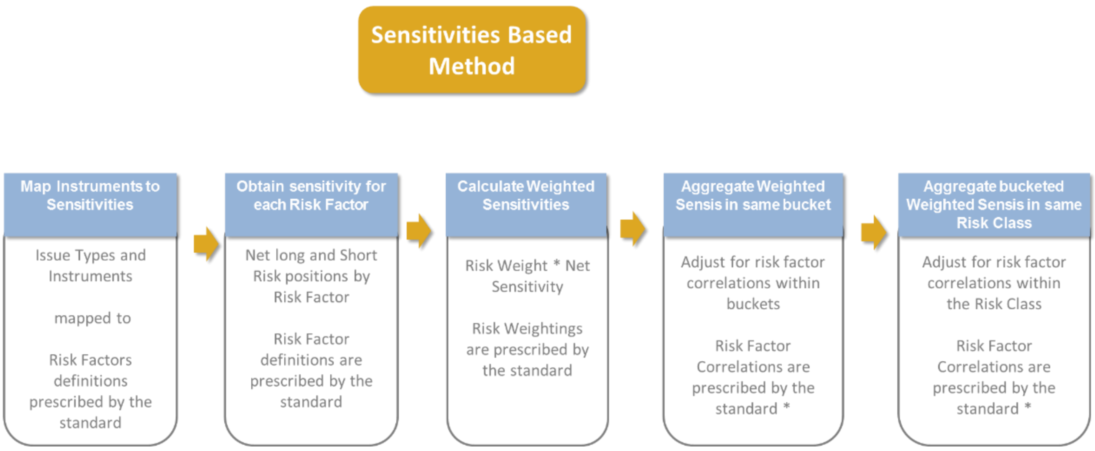
In addition to helping articulate the approach to senior management who might not be domain experts, Risk and Finance controllers will need powerful visualisation and quantification tools for determining the impact of curve differences. At each point along a curve or surface, the difference between two market data points can be visualised. This difference, whether in basis points, volatility points or credit spread, has a meaning in P&L or Capital Charge terms.

FRTB - Standardised Approach

If a trading desk cannot prove it is qualified to use the FRTB-IMA for calculating market risk capital, then it will need to use the FRTB-SA. FRTB-SA will result in a higher capital charge for the bank and its use will, therefore, result in a less profitable desk than would be the case with FRTB-IMA. For comparison purposes, all desks will also have to report FRTB-SA even if they operate under FRTB-IMA.

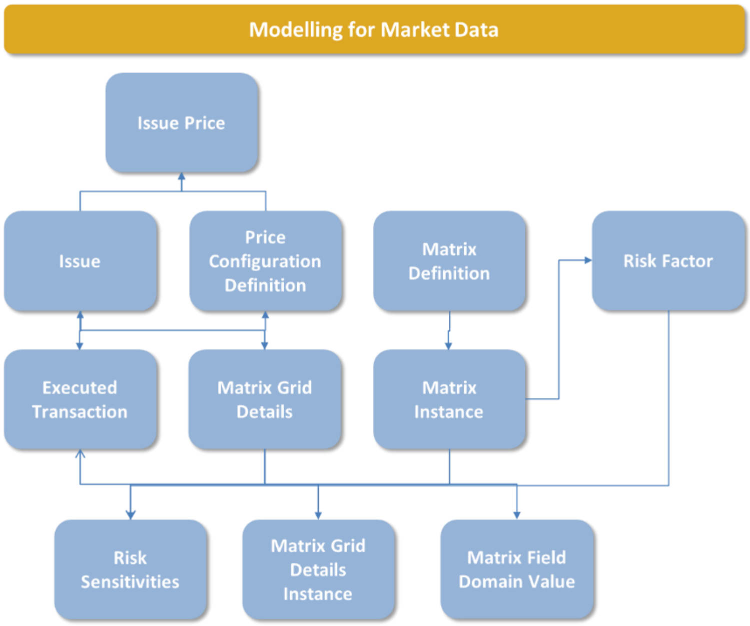
Risk Sensitivity Method

FRTB-SA requires the application of risk weights to risk sensitivities. Both the risk weights and the definitions of the risk sensitivities are prescribed in some detail in the Standard. A risk sensitivity definition is required for each risk factor. There are multiple risk factors within each risk class and there are seven risk classes in total (rates, credit, securitisation, equities, FX, commodity, credit correlation). Each risk factor can be de-composed into risk buckets. The risk buckets are groups of positions with similar characteristics that offer the potential to net long and short positions within the buckets. The netting of long and short positions reduces the capital charge and the Standard prescribes a set of correlations between risk factors that determine the level of netting allowed. The resulting bucket-level capital charges are summed to arrive at totals by risk class and an overall total.



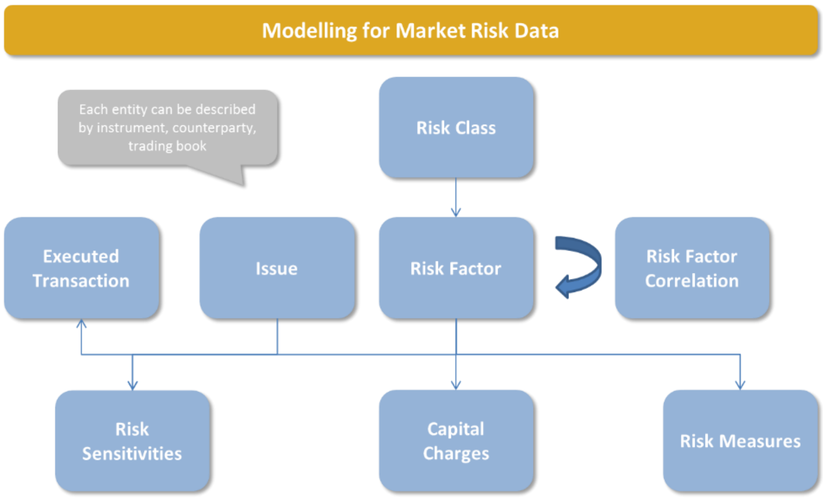
* Note: Positive correlations between risk factors with long positions will increase net weighted sensitivity amount. Negative Correlations between risk factors with long positions will decrease net weighted sensitivity amount

For ease of operational use the data modelling for market data must be designed to include screens and validation tools that are aligned with market standards. It is important that the raw market data, validation results and any derived pricing (discount factors, proxy pricing, calibrated values) is viewable and editable under 4-eyes principles. This will help to ensure common understanding and use of FRTB data throughout the organisation.



Data modelling for Market Risk sensitivities should be designed to both

- leverage the relationship between sensitivities and the market data to which they are sensitive and
- to facilitate efficient and accurate FRTB reporting and calculations



By ensuring that market data is validated and edited in a fully auditable environment and that the categorisation and taxonomy of market data is fully aligned with its corresponding market risk data, the bank will ensure that calculations are available, accurate and understood from the outset.

The essence of successful approaches to FRTB will be that once the upstream data has been specified and mapped properly, the calculations required for compliance will be relatively straight-forward. Take the capital charge for Risk Class "GIRR" (General Interest Rate Risk") as an example. This requires the application of risk weights to risk sensitivities along a standard set of vertices.

Calculate Weighted Sensitivities

Vertex	0.25 year	0.5 year	1 year	2 year	3 year
Risk weight (percentage points)	2.4%	2.4%	2.25%	1.88%	1.73%
Vertex	5 year	10 year	15 year	20 year	30 year
Risk weight (percentage points)	1.5%	1.5%	1.5%	1.5%	1.5%

An operationally robust FRTB capability will involve the population of meta-data for risk weights, risk factors and buckets, risk classes and capital charges. It will also require the mapping of instruments to the risk sensitivities and risk measures. The risk sensitivities will share the same parent risk factors as the curves that were used to create the sensitivities.

Risk factor correlations will then be required to allocate netting benefit or costs to eligible positions depending on how their risk factors are correlated with each other. The table below, again using risk class GIRR as an example, summarizes the correlation rules assumed in the Standard.

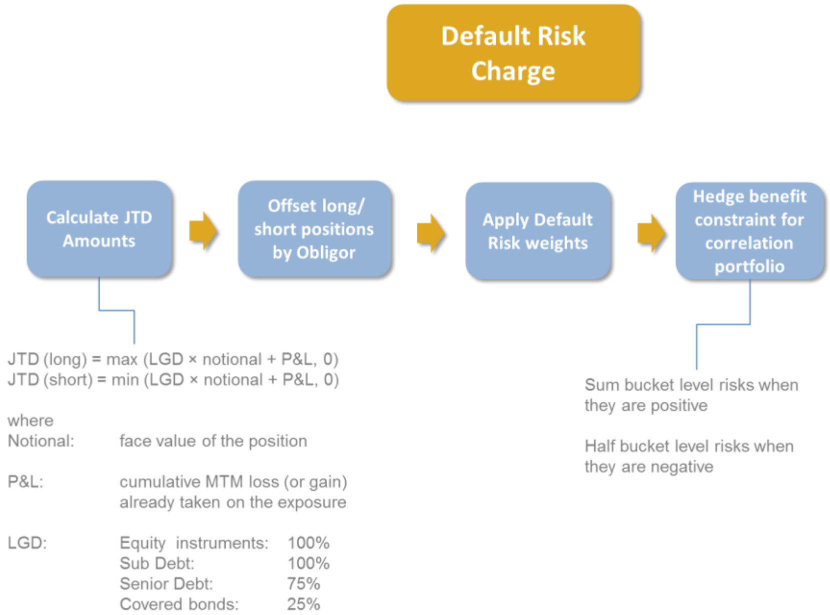
Risk Factor Correlations

Risk Sensitivity relationship to another risk sensitivity	Correlation to be used	Interpretation
Different Curve, Same Vertex, Same Bucket*	1	Long and short positions can be offset
Same Curve, Different Vertex, Same Bucket	$max\left[e^{\left(-\theta\frac{\lvert T_k-T_l\rvert}{min(T_k;T_l)}\right)};40\%\right]$	Θ is set at 3% by the standard. In effect, this means that correlation is approx 1 for two vertices with a time difference of a year or less. Correlations reduce from 1 as the vertex time differences increase. The formula implies a correlation of 0.4 for between the risks in the 1yr and 30yr vertices
Different curve, Different Vertex, Same Bucket	As above	As above
Interest Rate to Inflation risk factors	0.4	Interest rates are assumed to be positively correlated with inflation rates
Cross currency basis to interest rates	0	Xccy basis and Interest Rates not correlated
Cross currency basis to inflation rates	0	Xccy basis and Inflation not correlated
Aggregating between different currencies (buckets) *	0.5	When aggregating risk-weighted sensitivities across different currencies, a correlation of 0.5 should be used

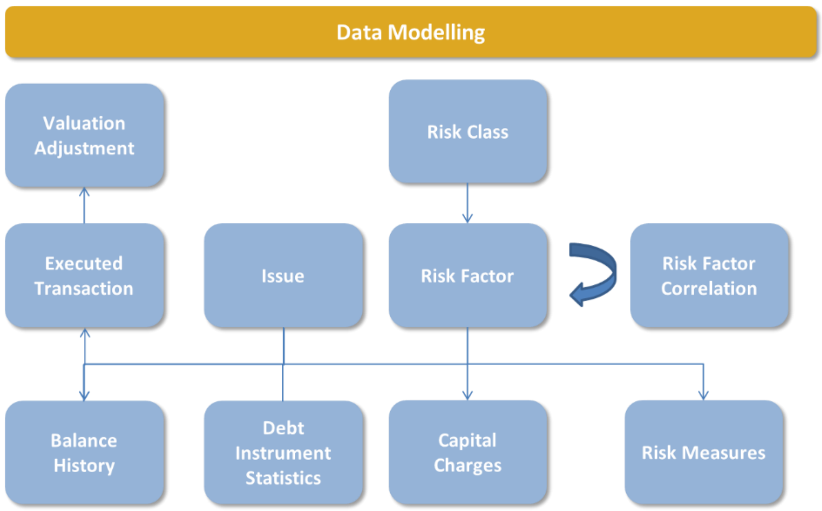
Apart from two of the scenarios (“Same Curve, Different Vertex, Same Bucket” and “Different Curve, Different Vertex, Same Bucket”), the correlations are simply numbers that have to be applied in the calculation that aggregates the risk weighted sensitivities. The other two scenarios require the use of an exponential function.

Default Risk Charge

The Default Risk Charge (DRC) under the FRTB-SA is intended to capture stress events in the tail of the default distribution which may not be captured by credit spread shocks in mark-to-market risk. Credit spread sensitivities capture market risk inherent in positions that are exposed to changes in the default risk of obligations. However, credit spread sensitivities are a market risk measure and they underestimate the potential loss from jump-to-default. Credit spreads measure the expected loss from default, which by definition is less severe that the default loss in the tail of the default distribution, and it is the default severity in the tail of the default distribution that is covered by DRC.



Data modelling for DRC requires the inclusion of LGDs, P&L history and, where required, cumulative CVA amounts. The diagram below provides an overview of the data modelling for DRC:



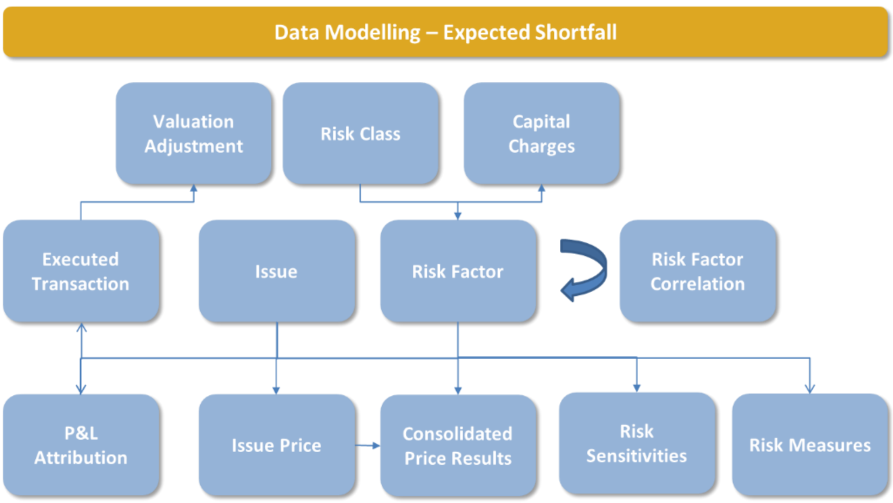
Data Modelling for DRC uses similar data to that used in the Sensitivity Approach. However, risk sensitivities are not required for the DRC. Balance history, in the above diagram, refers to cumulative P&L history. The Valuation Adjustment data is required to access cumulative CVA where required. Debt Instrument Statistic is required to access LGD percentages

FRTB – Internal Models Approach

Expected Shortfall

The regulatory capital charge for a bank will be based on the "*Expected shortfall*" (ES) risk measure. The ES value is calculated daily for the in-scope positions. In scope positions are determined by checks which are applied at trading desk level. The ES measure is based on the 97.5th percentile confidence level. In calculating the ES, liquidity horizons are used to scale an ES value which assumes a base horizon of 10. Part of the ES calculation involves the inclusion of a period of stress in the observation period. The correlations between risk factors that experienced the stress also need to be calculated. ES calculations require the input of both current (recent) observations and historical observations. For recent observations, banks must update their market and risk data at least once a month. The bank also needs to perform frequent market reviews to determine whether market prices are subject to changes material enough to alter the ES result. Flexibility is key here and the solution will need to allow users their own period of observation. The Standard states that the FRTB-IMA approach should, for example, allow a bank to calculate its Expected Shortfall using a shorter observation period where this is justified by an increase in market volatility. In this case, however, the period should be no shorter than 6 months. For ES calculations that use stressed observations banks need to specify the 12-month period of stress where the portfolio experienced the largest loss. The period needs to go back to and include 2007.

The aggregated capital charge trading desks approved for IMA will either be the most recent calculation or a weighted average of the previous 60 days – whichever is the largest. The result is scaled by a multiplier which ranges from 1.5 to 2.0 depending on the results of the VaR back-tests.



The Executed Transaction data is central to the modelling of OTC trades. Trades create market risk and accurate modelling of the relationships between trades and the risk sensitivities is critical for audit, data lineage and the ability to provide the detailed validation of FRTB calculations that the Standard demands. The Balance History entity could be used to record accounting and risk balances for both point-in-time and time-series reporting requirements. For FRTB, it can be used to store P&L time-series for ES calculations. A Risk Sensitivities table and a Consolidated Price Results table within a data model can be used to obtain Risk Factor attributable time-series P&L. The triangulation between risk sensitivities, market data and OTC trades needs to be modelled in such a way that ensures the integrity of the data and also minimises the complexity of any calculations that need to sit on top of the data. Where time-series valuation adjustments (e.g. for CVA) are required in calculations linkages will be required in the data model to support this.

IMA-Eligibility

A trading desk needs to prove it is qualified to use the FRTB-IMA for calculating market risk capital. Broadly speaking, it will need to pass two sets of tests in order prove it is IMA-eligible

- bank-wide qualitative tests
- trading desk-level quantitative tests

The qualitative tests requires that the regulator is satisfied that the bank has a robust risk management framework in place. This includes ensuring that there are a sufficient numbers of staff skilled in the use of pricing models across Front Office, Risk, Internal Audit and Finance. The regulator also needs to ensure that the bank has a proven track record of accuracy in measuring risk and that it conducts stress tests at frequencies sufficient to allow for the incorporation of market-disruptive events that might impact the parameters of FRTB calculations. The bank needs to ensure that the positions being held in the trading book that are being used for regulatory capital calculation purposes have passed the required trading-book eligibility tests. The frequency of back-testing and P&L attribution and confirmation that pricing models are being validated by a team that is independent from the trading desk are also key qualitative checks.

It should be noted that banks are permitted to use different models to calculate regulatory capital charges than those they use in the operation of their daily risk management tasks. As long as the pricing models that are embedded in both approaches are similar, and can be verified to produce similar results, the regulator will permit a separate calculation process for regulatory capital. The regulatory capital model needs to be based on the same methodologies as the operational model in terms not only of risk factor identification but also in relation to calibration tools and use of proxy pricing. This will require both automated proxy pricing and model parameter calibration.

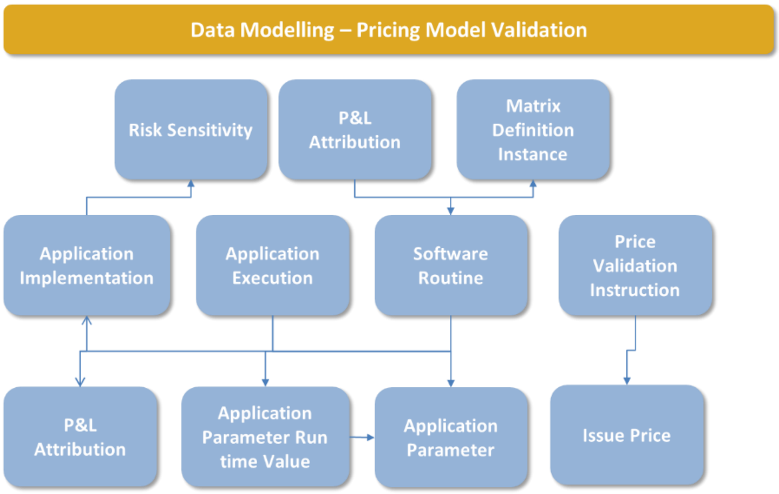
For a bank to be allowed to calculate capital using FRTB-IMA, it is mandatory that it has a robust set of Pricing Model Validation processes in place. A compliant FRTB ecosystem will be able to record definitions, inputs, outputs and approval statuses of “Pricing Models”. A common and well known example of a model is “Black-Scholes” – which is the industry standard model for valuing European call and put options. Other examples are SABR, Black’s Model, Monte Carlo and Base Correlation. Models are used to calculate the prices/values of positions in securities or derivatives. Models can be thought of as the implementations of the mathematics required to calculate fair value valuations. Most models are fair value or pricing models. A simple example of a pricing model is V=P*Q. Where V= the valuation of the security, P is the price of the security and Q = the amount of the security the bank is holding. When calculating the V for derivatives, e.g. call options, however, you need to take account of the fact that the option will only have a value if the P (P in this case would be the Price of the underlying Security) is greater than the strike. So you need to know the probability of P being greater than the strike at maturity – so the model becomes more complicated requiring interest curves and probabilities as inputs. Probabilities of the underlying prices are derived using market volatilities of those prices.

The data modelling for Pricing Model Validation needs to be able to capture

- the Library that model or routine belongs to
- the name and version of the model or routine
- the list of market data inputs to the model

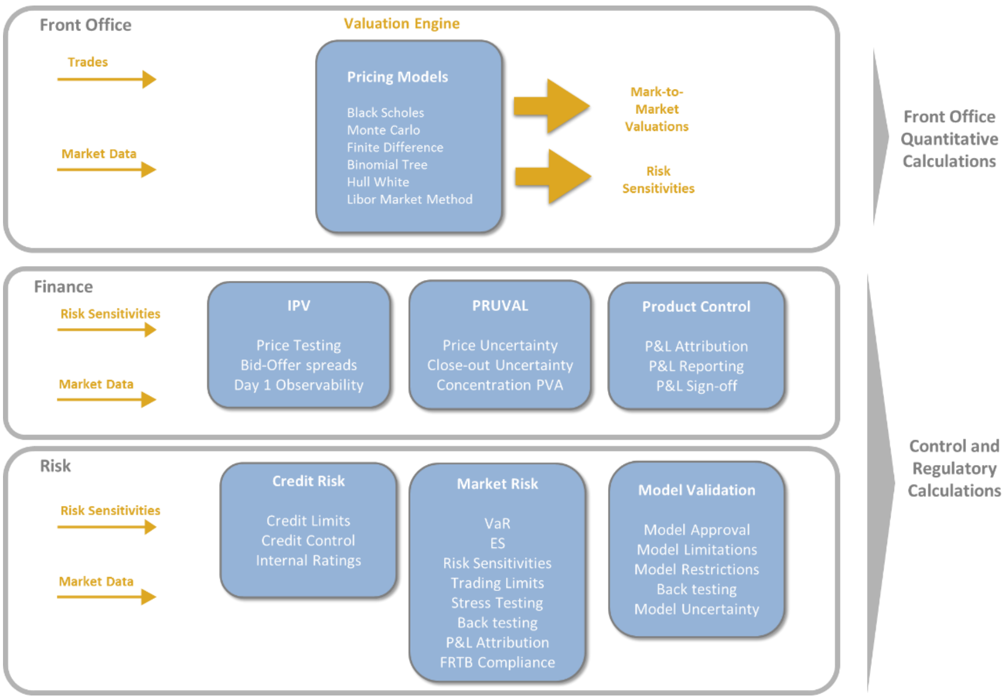
- the list of parameter inputs to the model
- the last calibration date of the parameter inputs
- the Model approver
- the Last Validation date of the model

The diagram below gives an overview of the type of data entities that would be required for modelling Pricing Model Validation



Quantitative Model Validation Tests

The primary quantitative tests for IMA-eligibility are the IMA Model Validation tests. It is important at this stage, however, to differentiate between Pricing Models used to calculate fair values of derivative and other held-for-trading positions and Models used in Risk and Finance for Control and Regulatory calculations



Per the diagram above,

- “Pricing Models” are quantitative models used to calculate the fair values of derivative and other held-for-trading positions. They are either developed in-house by the bank’s Quantitative Research team or they are routines or models that come with 3rd-party libraries. As described above, examples are SABR, Black-Scholes and the Hull-White interest rate model.
- “Control and Regulatory Calculations” are a separate set of calculations that sit downstream of (or beneath in the case of the diagram above) Front Office Pricing Model calculations. Expected Shortfall, the aggregation of risk sensitivities across correlated risk factors, Value-At-Risk, P&L Attribution, Bid-Offer Reserves calculations, CVA, FVA, Market Price Uncertainty, and Close-out Costs Uncertainty are all examples of Control and Regulatory calculations that are owned typically by either Risk or Finance.

It is these Finance and Risk Control and Regulatory calculations that the Basel Committee were looking to address when they came up with their IMA Model Validation tests. Specifically they were looking to ensure that these Control and Regulatory calculations were

- used a set of calculations prescribed by the standard and accepted by the industry
- based on consistent data sets and methodologies across Risk, Finance and the Front Office

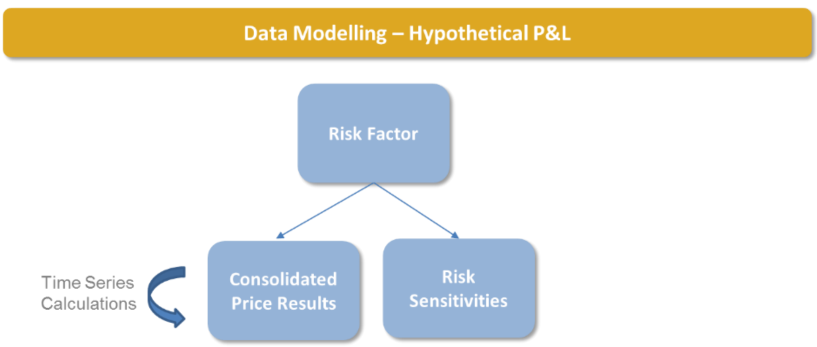
The two key tests that FRTB-IMA expects a Trading Desk to pass (in order for it to be able to calculate capital using FRTB-IMA

- a VaR back-test (more rigorously enforced than in prior market risk standards)
- a P&L Attribution test

If a trading desk fails to pass either of these quantitative tests, it will need to revert to the Standardised Approach.

VaR Backtesting is to be carried out against 97.5% and 99% VaR on a 1-day horizon, and will need to be performed against the trading desk’s hypothetical P&L. The Standard defines hypothetical P&L as the gains or losses that would have arisen from holding position quantities constant and just applying market data moves to them over the period in question. From a data perspective, and in the context of the GoldenSource Curve Shift methodology described above, this would involve

- mapping market data points to risk sensitivity points
- “shifting curves” by daily moves in market data
- applying the daily “curve shifts” to risk sensitivity positions



The time-series curve shifts applied to the starting risk positions will result in a distribution of hypothetical daily P&L values by risk factor. 1-day 99% and 97.5% confidence intervals (CIs) can be determined using the distribution. An outlier occurs whenever a historical daily hypothetical P&L is greater than the VaR at 99% CI. In a year with 260 trading days, at the 99% CI the bank would expect to have no more than 3 back-testing breaks (rounded up from 2.6). If there are greater than 3, the risk management model will be deemed suspect under the Standard and will require investigation and potential remediation.

It should be noted that this is a test of the VaR model and not a test of a VaR limit. It is a test of the VaR model that will be used to calculate a VaR risk measure. In fact, indirectly, the approach tests both the VaR model and the Front Office Pricing Models simultaneously. This is because

- the risk sensitivities used in the calculation will have been created using the bank's Front Office pricing models
- there is no 'noise' from position amendments, fees, commissions etc., and, finally
- the VaR CI is calculated using clean historical P&L values create by Front Office Pricing model.

If the VaR model is accurate the number back-testing breaches should be very close to the number that the model predicts

As mentioned above, a compliant FRTB ecosystem will need the ability to both

- store all the time-series data required for the FRTB-IMA VaR calculations and
- to integrate with a model-validated calculation engine to support a parameterised approach to these calculations.

So, should a trading desk use risk sensitivities for its VaR back-test or should it use a full revaluation approach? The Standard, in fact, is not prescriptive on this question. Note that P&Ls used for the VaR back-test are calculated across all risk factors that the trading desk is exposed to, irrespective of whether a full revaluation approach or a risk-sensitivity approach is used. If the bank uses a risk sensitivity approach then, for example, a 10-day P&L will be generated for each risk sensitivity that the desk is exposed to and the resulting P&Ls will be aggregated into a desk level P&L. If, on the other hand, the bank uses full a revaluation approach for VaR then the full revaluation model will take as input the market data for each risk factor in the model and use this market data to generate fair values for the desk's trades/positions. The difference between this value and the value generated from the market data from 10 days ago will be the full revaluation P&L.

Dashboards and KRIs tailored to senior management requirements will be required to highlight any back-test breaches.

FRTB is driving an alignment of models and data between Risk and Finance

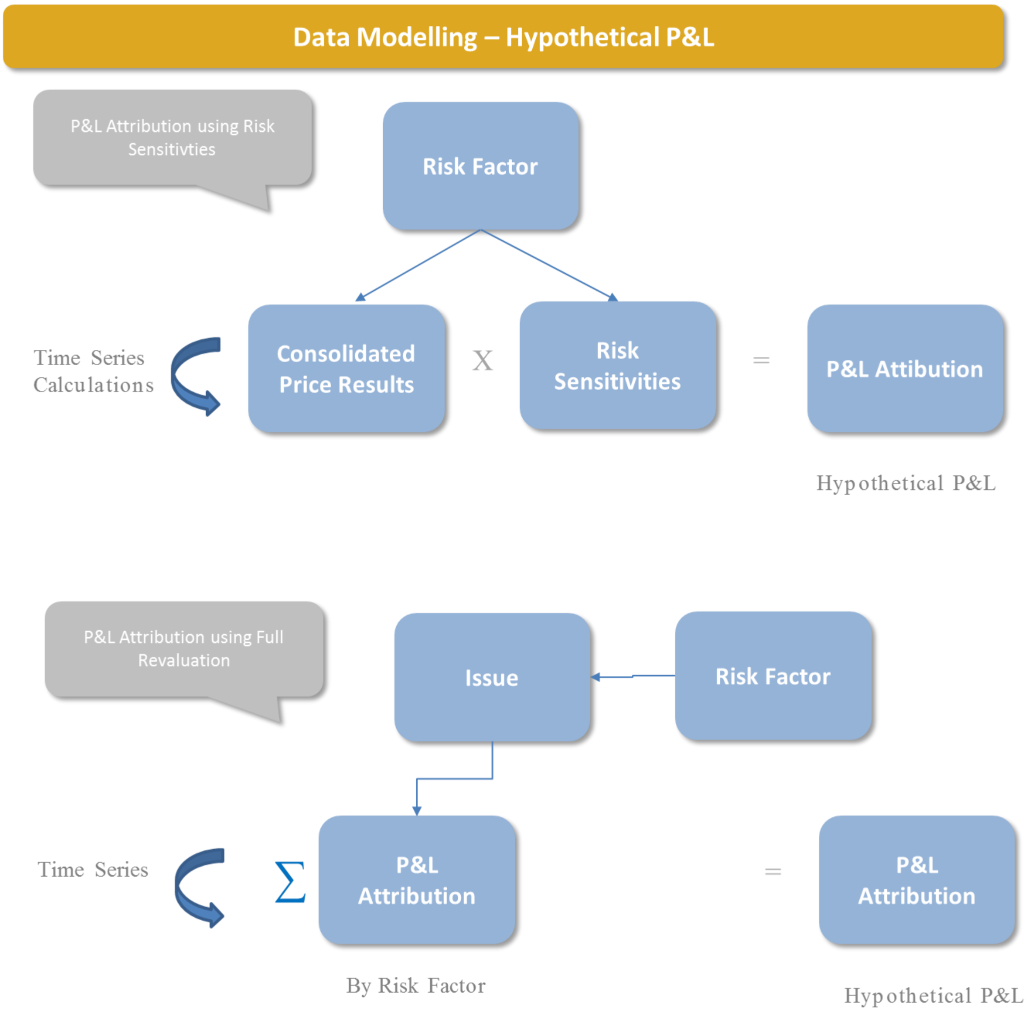
While back-testing has always been a requirement, the need to pass a *P&L Attribution* test is new. It revolves around the concepts of Risk-Theoretical P&L and Hypothetical P&L. Like the VaR back-test, it is a test that is applied at trading-book level. Risk-Theoretical P&L is P&L calculated in Market risk models. Hypothetical P&L is the Front Office or Official P&L over the same period assuming that positions are held constant and market moves are applied to them. From a regulatory perspective, the aim of the P&L Attribution test is to test that Risk models used for capital calculations are closely aligned to Front Office models (i.e. models used for Official Valuations which are in turn used in Product Control for Daily P&L purposes). There are three broad drivers that can cause divergence between the results of Risk and Finance models:

1. The definition of the risk factors that determine the market data inputs
2. The market data itself

3. The valuation methodology, i.e. full revaluation vs risk factor sensitivity based approximation.

As mentioned above, with regard to the valuation methodology, FRTB does not prescribe that risk models use full revaluation but, one of the arguments being made by industry practitioners at the moment is that full revaluation will essentially be enforced by the standard in that if the risk models do not use full revaluation then P&L Attribution test will likely fail.

The data modelling diagram below provides a high level overview of the data entities required under both a full revaluation and a risk sensitivity approach.



In terms of the actual test that is applied for P&L Attribution, on a daily basis, an Unexplained P&L value needs to be calculated where

Unexplained P&L = Risk-Theoretical P&L less Hypothetical P&L.

The P&L Attribution test applied consists of two sets of thresholds that are calculated monthly using the daily P&L data:

- Ratio of mean unexplained daily P&L to standard deviation of hypothetical daily P&L is between -10% and +10%:

$$\frac{\frac{1}{N}\sum_{i=1}^{N}(\text{PnL}_{Risk} - \text{PnL}_{Hypo})}{\sigma_{\text{PnL}_{Hypo}}}$$

- Ratio of variances of unexplained daily P&L and hypothetical daily P&L is less than 20%

If either of these sets of thresholds are breached, then a P&L Attribution break has occurred. And where 4 or more breaks have occurred within the prior 12-month period, the trading desk will revert to capitalisation using FTRB-SA. This will be quite a difficult test to pass for many trading desks. Most banks use risk sensitivities and not full revaluation to calculate market risk regulatory capital, while a desk's P&L will always be calculated using full valuation within the pricing model (even if that P&L is often attributed using risk sensitivities). It might mean that in order to pass the P&L Attribution test, the bank will either need to move to full revaluation for its IMA calculations (computationally expensive), or it will need to increase the granularity of the risk sensitivities used its IMA calculations.

Is the P&L Attribution Test Too Penal?

An emerging view among industry practitioners is that the P&L Attribution test will fail more often than it should and for the wrong reasons. There are a number of reasons for this view

One of the metrics (the second metric, in fact) in the test is the ratio of variances of unexplained daily P&L to hypothetical daily P&L. This metric can explode very quickly in a very well hedged book. To understand why, note first that for a very well hedged book there is unlikely to be much variation in hypothetical daily P&L because, by definition, if the book is very well hedged, then the hypothetical P&L, which excludes fee income, will remain constant because the market risk has been hedged out of the book. In this case, the book will make its P&L only from the fees that have been deliberately excluded from the hypothetical P&L calculation. Again by definition, if hypothetical daily P&L is close to constant, its variance will be close to zero. And, since this variance is the denominator term in this second of the P&L Attribution metrics it will result in a very large number because dividing by a number close to zero will result in a large number. This is an example of the P&L Attribution test failing for the wrong reason. The test fails in this instance not because of misalignment between Risk and Finance models but because a desk is not exposed to market risk. And I'm sure the Basel panel did not set out to penalise desks for not taking market risk!

It is also possible for a desk to fail its P&L Attribution test because of methodology differences between Risk P&L and Finance P&L calculations. Take bank holidays, for example. On bank holidays Finance typically do not book P&L. Risk, on the other hand, calculate Risk on bank holidays based on prior day positions. And it is possible for desks to fail P&L attribution tests for this reason.

From an FRTB system perspective, a robust P&L Attribution methodology will use dashboards, KRIs, Near-Miss reporting analysis and reporting of Model Validation testing results to ensure potential breaks are flagged as early as possible.

Non-Modellable Risk Factors

Only those risk factors which are considered modellable will be eligible to be included in a trading desk's FRTB-IMA calculations. According to the Standard, for a risk factor to be classified as modellable, there must be "continuously available *real* prices for a sufficient set of representative transactions". A price will be considered real if it is based on either a traded price or on a "committed" quote.

Non Modellable Risk Factor (NMRF) analysis is multi-faceted. The analysis includes:

- identification of the bank's own traded prices for the risk factor
- identification of the external market traded prices for the risk factor
- identification of committed quotes for the risk factor
- risk factor by trade analysis
    - identification of the risk factors that are included in a traded price. For derivatives there can be multiple risk factors in a single traded price
    - consideration of how risk factor prices can be backed out of traded prices
- identification of model-derived risk factor prices. This will typically mean derived model prices that are based on real inputs
- identification of the stressed period that the risk factors are being calibrated to for the purpose of real price identification
- analysis of CSA's (Collateral Support Annexes) to identify daily margined OTC trades. There is an argument to state that fully collateralised trades are evidence of real prices for the risk factors that these trades are exposed to

The main difficulty in NMRF analysis will be in the identification of "committed" quotes. The industry has no firm definition yet of what qualifies as a committed quote. Given this, can it be assumed that the primary source of real price data will be trades (as opposed to quotes)? To a certain extent the industry is still grappling with these questions. Solutions still need to emerge.

Vendor versus In-House Solutions to Real Price Identification

Market data vendors are working hard at identifying solutions for identifying real prices and aggregating real price data. When these solutions do emerge it will be interesting to see the shape that they take and their consistency across vendors. Some questions are

- Will consensus price vendors amend existing price submission processes to allow banks to submit real price flags?
- How will vendors aggregate real price data? Will they try and determine, effectively guess at, the shape of a typical bank's risk factor given that they will have no transparency on the risk positions a bank runs?
- Will individual vendors have different ratios of traded price data to committed quotes? Will some vendors specialise in quotes whereas others will only have access to trades?
- Will vendors calculate Risk Factor modellability themselves? Or will they just send real prices to banks? If the former, then, again, how will they determine what a Risk Factor should look like for a bank given that they have no transparency on a bank's risk positions?
- Will banks in a particular region club together to collate real price data common to them?
- If vendors do support determination of Risk Factor modellability, what kind of approximations will they support? Will, for example, all interest rate swaps with a maturity of approximately 1 year be included in their 1 year maturity real price determination? Is the underlying tenor of the swaps (e.g. 3m vs 6m) relevant? While aggregating data into maturity buckets, what kind of interpolation logic will be applied?

At the time of writing, these questions remain largely unanswered. As NMRF solutions evolve over the coming months and years, they need to be answered

How will banks use the real price data?

As mentioned above, market data vendors will not know what a bank's risk positions are. They will, therefore, not also know what Risk Factors it has exposures to. One consequence of this is that one of the key features of a compliant FRTB ecosystem will be the ability of the system to link (external) real price data to its (internal) risk factors.

GoldenSource MDS is uniquely positioned as a product to support this requirement. Not only does it have adaptors to all of the major market data vendor feeds, it also has the ability to allow banks to define their own adaptors to in-house real price feeds should they choose to do so. More important than this, it also has the ability to link the real price data to internally-defined Risk Factors for modellability determination.

Criteria for real price determination

An executed trade is clear evidence of a real price. There isn't really a lot of room for interpretation there. The size of the trade and the potential for collusion between trade counterparties to create a trade that will support a regulatory capital target are two potential exceptions to this. But there are not many. With committed quotes, however, things are less clear. Some or all of the criteria below should be taken into account to identify committed (executable) quotes:

- Both "bid size" and "ask size" need to be available from the contributor to be deemed executable
- Exchange prices (futures, options, equities) are typically executable quotes
- Bond prices from bond trading platforms are typically executable quotes
- Prices from SEFs (swap execution facilities) are typically executable quotes
- Composite prices are not executable
- Evaluated prices are not executable
- A mid price on its own (from any source) is not executable
- A model price can only be considered executable if
    - all of the inputs to the model are real
    - bid and ask prices can be backed out from the model

NMRF Overlap with other regulations

The concept of a committed quote in FRTB NMRF analysis overlaps with concepts from other regulatory and financial reporting standards. For example,

- An FRTB committed quote has similar characteristics to an executable price (where an executable price attracts a zero AVA) in CRD4 Prudential Valuation (PRUVAL) standards
- Level 1 positions in the IFRS fair value hierarchy can be deemed to have similar liquidity characteristics to those of both FRTB committed quotes and PRUVAL executable quotes

Conclusion

The numerous data-related considerations to be factored into the design of FRTB approaches act as the devil in the detail for an otherwise prescriptive regulation. The delta between existing system, modelling and process capabilities, particularly related to the handling of deeply granular data, will determine the effort required to reach a smoothly operating FRTB ecosystem within the bank.

We hope this paper has informed your methodology and design process, and that any Request for Information sent out to 3rd parties will be more comprehensive as a result of the knowledge and opinions we have shared.

GoldenSource proposes the Curve Shift methodology as a practical, robust operational approach to addressing risk-related control and regulatory challenges. One of these is certainly FRTB and our solution here supports the associated data management, calculations, validations and data storage requirements. Banks that have a partial solution within their existing system landscape can augment this with modules from the GoldenSource solution.