Aptivaa

LEADING THROUGH INNOVATION

Market Risk Data Analytics

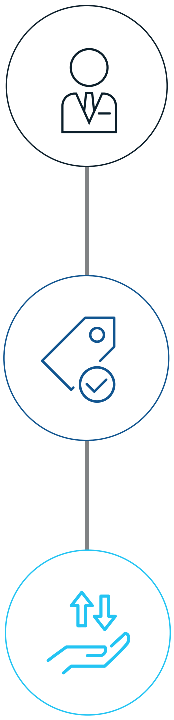
Taxonomy, Lineage and Definitions

Market Data

This note aims to arrive at a standardized taxonomy for market risk data to better communicate information around recent regulatory guidance for market risk management and capital charge computation. We aim to build a common nomenclature to be used between management, analytics teams and the IT departments deriving from the regulatory definitions.

Market data includes the prices, rates or quotes of traded instruments in the market place (exchange traded instrument - cleared through CCP, or bilateral trades through the OTC mechanism). Examples include swap rates term structures, rate indices (SOFR, EONIA rates, CDS spreads, commodity prices, volatility quotes and futures prices.

Market data can be introduced to the market risk ecosystem from a number of different sources, as depicted below:



Snapped and End-of-Day vendor feeds

Ticking prices (snapped or filtered)

Front offices trading systems

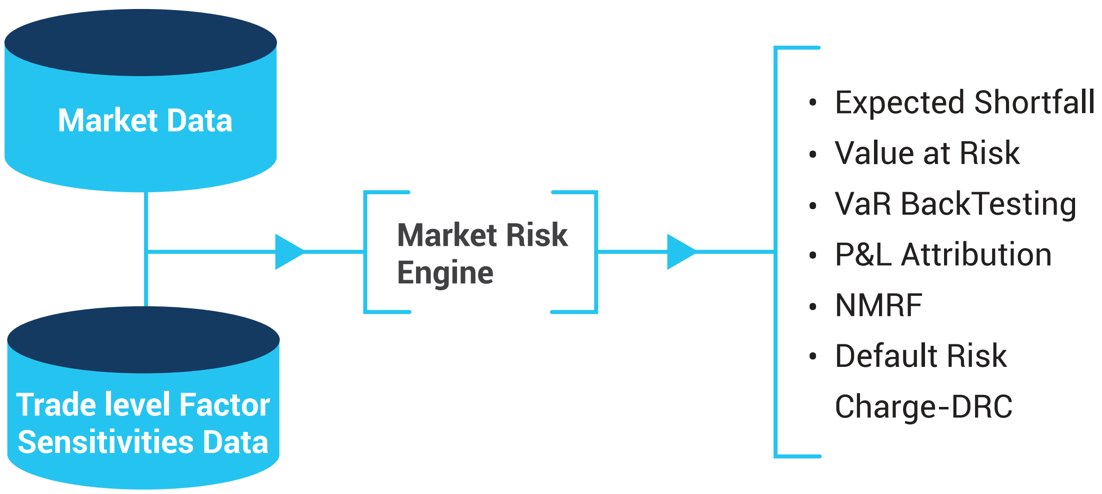
Position and Transaction Data for Market Risk System

Position and Transaction (P&T) data will be introduced to the market risk ecosystem from the bank's front office, and risk and finance systems. This is internal proprietary data. Other banks will not and should not be aware of the positions/trades the bank is running. For the purpose of this document, "P&T data" shall be a generic term that shall cover the following categories of internal data:

1. Trade level Risk Sensitivities
2. Position level Risk Sensitivities
3. Trade level P&L
4. Position level P&L
5. Portfolio level P&L
6. Risk Factor level Sensitivities

The inputs, processes and outputs used to generate market risk matrices are illustrated below

Market Risk System Data Flow Structure



Instruments and Market Data

Three basic categories of instruments can be defined with respect to market data:

- **Type 1 :** Securities or Cash instruments
- **Type 2 :** Quote instruments
- **Type 3 :** OTC Derivatives

INSTRUMENTS	MARKET DATA INSTRUMENT	TRADABLE	CONTAIN NOTIONAL VALUE	CONTAIN MTM VALUES
Type1: Securities & Cash Instruments Example : Equities ,Bonds , FX Spot	Yes	Yes	Yes	Yes
Type2: Quote Instruments Example : IR Swap Rate, FX Forward Rate, FX Fixing	Yes	No	No	No
Type3: OTC Derivatives Example : IR Swap,FX Forward,FX Option	No	Yes	Yes	Yes

Such an asset classification is a significant first step in shedding light on market data quality and issues regarding market risk, P&L and valuation risk. However, as workflows continue to evolve significantly beyond simple classification, a three level classification of market data as per the below table is warranted:

Level 1
Level 2
Level 3

- Observable inputs
- Quoted prices for identical assets / liabilities in active markets
- No adjustment for size / liquidity
- Example asset classes include exchange traded equities, derivatives and funds; highly liquid fixed income instruments (e.g. US Treasuries)

Level 1
Level 2
Level 3

- Quoted prices for similar assets and liabilities in active markets
- Includes prices for proxy instruments
- Quoted prices for identical instruments on not active markets
- Other observable model inputs (e.g. interest rates / yield curves, volatilities, prepayment speeds, loss severities, credit risks, default rates)
- Inputs derived from observable market data by correlation or other means
- Example asset classes include most fixed income instruments, interest rate swaps and money market funds

Level 1
Level 2
Level 3

- Inputs into the valuation methodology are unobservable and significant to the fair value measurement
- Includes internally derived analytics and data
- Example assets include distressed credit

Data Lineage Problems

In the sub-section "Instruments and Market data" above, three categories of instrument identifiers were introduced:

- **Type 1** : Securities or cash instruments
- **Type 2** : Quote instruments
- **Type 3** : OTC Derivatives

This section describes some instrument lineage requirements using a Type 3 instrument identifier example. Type 3 instrument identifiers are identifiers for OTC derivatives.
Some important features of OTC instruments are:

- OTC instruments have a single, typically in-house generated identifier
- OTCs do not have a price, they instead have "mark-to-market" (MTM) or PVs
- OTC instrument identifiers can have data relationships to the Type 1 and Type 2 instruments that either form part of the OTC terms and conditions or are used to value the OTC .

Lineage from the OTC instrument identifier to related Type 1 and Type 2 instruments as well as source data should be maintained at all times.

Instead of a single price, an OTC derivative typically has multiple risk factors, each of which has a price. And even though the OTC has multiple risk factors, it has only one MTM value, and an MTM value is not a price.The MTM value (or PV) is instead a dollar amount equal to the present value of the future cash flows of the OTC.

To calculate the PV of OTC derivatives a pricing model is required. The model takes each risk factor as an input and revalues the MTM each day. The following is an example:

Type 3 instrument

FX Option –USDJPY Fwd Option 5Yx 10Y
OTC Instrument Internal id=FXOPT0986

Risk Factors [as per the mathematical definition of the pricing model, e.g. Black Scholes]:

- Risk Factor 1: the Underlying FX Rate [USDJPY]
- Risk Factor 2: the Interest Rate Curve for USD & JPY
  - USD.SOFR
  - JPY.TONAR
- Risk Factor 3: Volatility of the FX.FWD.USDJPY rates

Risk Factor Inputs to the Pricing Model today:

- Risk Factor 1: The FX.USDJPY Rates
- Risk Factor 2: The Interest Rate Curve for the USD & JPY Currency
  - USD.SOFR Curve
  - JPY.TONAR Curve
- Risk Factor 3: The FX. USDJPY Vol Curve risk factor dimension would be 3D
  - Level of Moneyness [ATM, ITM, OTM]
  - Option Maturity [6M,1Y,3Y,5Y,10Y]
  - Underlying Tenor [3M, 6M ,1Y,3Y,5Y,10Y]

The Total RFs required to perform Vega calculation would be = 3 Level of Moneyness x 6 underlying Tenor x 5 Option Maturity = 90 RFs

Data lineage is critical for effectively defining market risk factors and its utility in regulatory capital calculation [eg FRTB] that has to comply with ECB /TRIM/FED guidelines on effective model risk management [MRM].

The ability to trace the model inputs back to source and with a full audit trail of the various transformations that have been applied (derivations, calibrations, golden price rules, etc.), is seen as critical by auditors and regulators alike. Some of the key aspects of data lineage for model risk management are

- **Instrument lineage**
- **Data normalization**
- **Aggregation keys**
- **The transformation of raw market data inputs into calibrated inputs that models can understand**
- **The linkage of market data points on curves and surfaces to risk sensitivity buckets**
- **The model approval process and ability to have APIs from data systems to internal quantitative libraries**

Market Risk Factors – RFs definition

For the risk factors identification process to be compliant as per the FRTB regulation, the FRTB regulation requires each risk factor to be mapped to a regulatory risk class, risk factors-RFs category and liquidity horizon of RFs.

Risk Factors definition for Internal Models		Liquidity Horizon				
Risk Class	***Risk Factor Category***	*10D*	*20D*	*40D*	*60D*	*120D*
Interest Rate	Interest Rate-Domestic Currency of a Bank - EUR,USD,GBP,AUD,JPY,SEK ,CAD	√				
	Interest Rate Other Currency -MYR ,SGP,CNY,SAR,INR		√			
	Interest Rate ATM Volatility				√	
	Interest Rate [Other than Yields & ATM Vol]				√	
Credit	Central Govt incl central bank of member states of the Union		√			
	Covered Bonds issued by Credit Institutions established in member states of the Union [IG]		√			
	Credit Spread-Sovereign [IG]		√	√		
	Credit Spread-Sovereign [HY]			√		
	Credit Spread-Corporate[IG]				√	
	Credit Spread-Corporate[HY]					√
	Credit Spread-Volatility					√
	Credit [Other]					
FX	FX-Rate-Liquid Currency pairs	√				
	FX-Rate-[Other Currency pairs]		√			
	FX Volatility			√		
	FX (Other)			√		
Equity	Equity Price [Large Cap]	√				
	Equity Price [Small Cap]		√			
	Equity Price [Large Cap] Vol		√			
	Equity Price [Small Cap] Vol				√	
	Equity Other				√	
Commodity	Energy Price		√			
	Other Commodities Price		√			
	Energy Price Vol				√	
	Precious Metal Price				√	
	Precious Metal Price Vol				√	
	Other Commodities Price Vol					√
	Commodity Other					√

Let's take a real example to understand how we can define and retrieve risk factors from trading book portfolio.

RISK FACTORS-RFS IDENTIFICATION PROCESS

Step -1	Identify Relevant Risk Factors	• Retrieve the Universe/DBs of relevant RFs from all the trading book positions • Justify and documents if any risk factors is omitted from Product Valuation/Pricing Lib
Step -2	Create Product Mapping	• Create mapping rules for Identified RFs to a set of Instruments & Risk Classes • RFs can be overlapping to Multiple products /Positions
Step -3	Price/Quote Observability Check	• Retrieve vendor and Internal bank transaction data and map back to RFs using set of mapped Instruments/products from Steps-2

RFs Repository

Identify Relevant Risk Factors

RFs ID	RFs	Risk Class	LH
101	Swap_USD_3M	IR	10_D
102	Swap_EUR_1M	IR	10_D
103	CDS.USD.IBM.10Y	CR-Securitization	120_D
104	CNY.JPY.6M	FX	20_D

Mapping Rules for Instruments /Products Sets

Create Product Mapping

RFs ID	RFs	Products	Currency	Maturity Bucket
101	Swap_USD_3M	IRS	USD	[1M,5Y]
102	Swap_EUR_1M	IRS	EUR	[5Y,20Y]
103	CDS.USD.IBM.10Y	CDS	USD	[3M,15Y]
104	CNY.JPY.6M	FXFWD	CNY.JPY	[1M,2Y]

Mapping Rules for Instruments /Products Sets

Price/Quote Observability Check

RFs ID	RFs	Products	Currency	Type
101	Swap_USD_3M	IRS	USD	Quote (Q2)
102	Swap_EUR_1M	IRS	EUR	Transaction(Q1)
103	CDS.USD.IBM.10Y	CDS	USD	Quote (Q3)
104	CNY.JPY.6M	FXFWD	CNY.JPY	Transaction(Q1)

Q2- Committed Quote
Q3- Third Party Vendor Data Sources
Q1-Transaction-Real Price

Risk Factors' Definition for Internal Models

RFs can be defined as "a principal determinant (PCA) of the change in value of a transaction" that is used for the quantification of risk.

Interest Rate Risk Factors

- Yield curve used to quantify GIRR must be segmented into maturity buckets and modelled using a minimum of Six distinct Risk Factors, each representing a specific vertex of a maturity segment.
- Yield curve must be segmented into FRTB defined maturity buckets.
- Yield curve must be modelled using six distinct risk factors representing a specific vertices of a maturity segment.

Volatility Surface Risk Factors

Any Vol Surface has three dimensions
1- Option Expiry [3M , 6M , 1Y ,3Y, 5Y, 10,12Y,15Y,20Y,25Y,30Y]
2- Underlying Expiry [Maturity Bucket]
3- Moneyness [ATM , ITM , OTM]

Number of RFs = Number of Option Expiry x Number of Underlying Expiry x Number of Moneyness

- Each bucket represents a different RFs, Standard Volatility model like SABR model where the calibration parameters and inputs are considered as RFs.
- All the RFs relevant for pricing an instrument should be captured by the bank's internal risk model (ES)
- Any omission of RFs that are used to price an instrument but are not captured in the risk models needs to be justified by the bank, and it must be properly documented.

Calibration of SABR model

For each option maturity and underlying, we have to specify 4 model parameters σ, ρ, β, α. Market implied volatilities for several different strikes are needed for the same. Given this, the calibration poses no problem. For example, one can use the excel solver ability.

SABR Vol Model		
MRFs	NMRFs	Descriptions
Implied Vol	σ	The Vol of Vol σ , which mainly influences the curvature.
	ρ	The Leverage ρ , which mainly influences the skew.
	β	The Beta β , which mainly influences the skew.
	α	The Initial Volatility α , which mainly influences the Implied ATM Vol

Inputs Imp Vol for several different strikes

Calibration results show an interesting term structure of the model parameters. An example for these model parameters may be the parameters of a displaced SABR model σ, ρ, β, α.

SABR Risk Factors (RFs)	
Data	Interpretation
σ (K1).....σ(Kn)	Raw market data Implied Vol : Using these as a RFs would imply that we have a large set of RFs. Using the large set in P&L and a sub set for risk will likely result in a failure of the P&L attribution criteria.
σ, ρ ,β ,α.	Model Parameters : Using these RFs may lead to exaggerated scenarios
σ'' (K1).....σ'(Kn)	Calibrated Imp Volatilities : Exact P&L Attribution , usually well behaved scenarios
ATM Vol , Risk Reversal , Butterfly etc.	Derived smile properties from Calibrated Curve : Exact P&L attribution, usually well behaved scenarios. Parsimonious RFs set m < nn . Improved orthogonal of Risk

Non Modellable Risk Factor (NMRF)

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 collateralized trades are evidence of real prices for the risk factors that these trades are exposed to

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

Contact Us

Feel free to send your queries to:

Masoom Khan
Author | Associate Director
Market Risk Analytics & FRTB,
CQF, MSc-Economics, FRM
Email : masoom.khan@aptivaa.com
Phone : +91- 98193- 72241
+91- 22- 40838600

Mr. Khan has been into Market Risk Analytics, Regulatory Capital and FRTB project from past 12 years, worked with CitiGroup, Calypso and Bank of America [BAML] on Market Risk Analytics & Regulatory Capital project.

Aptivaa

Aptivaa is an established services provider, offering comprehensive analytical solutions, for clients in banking, insurance and other financial services. Globally, we have worked with several clients to enable them to successfully navigate the ever-changing regulatory & business environment in the area of Financial Risk Management.

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