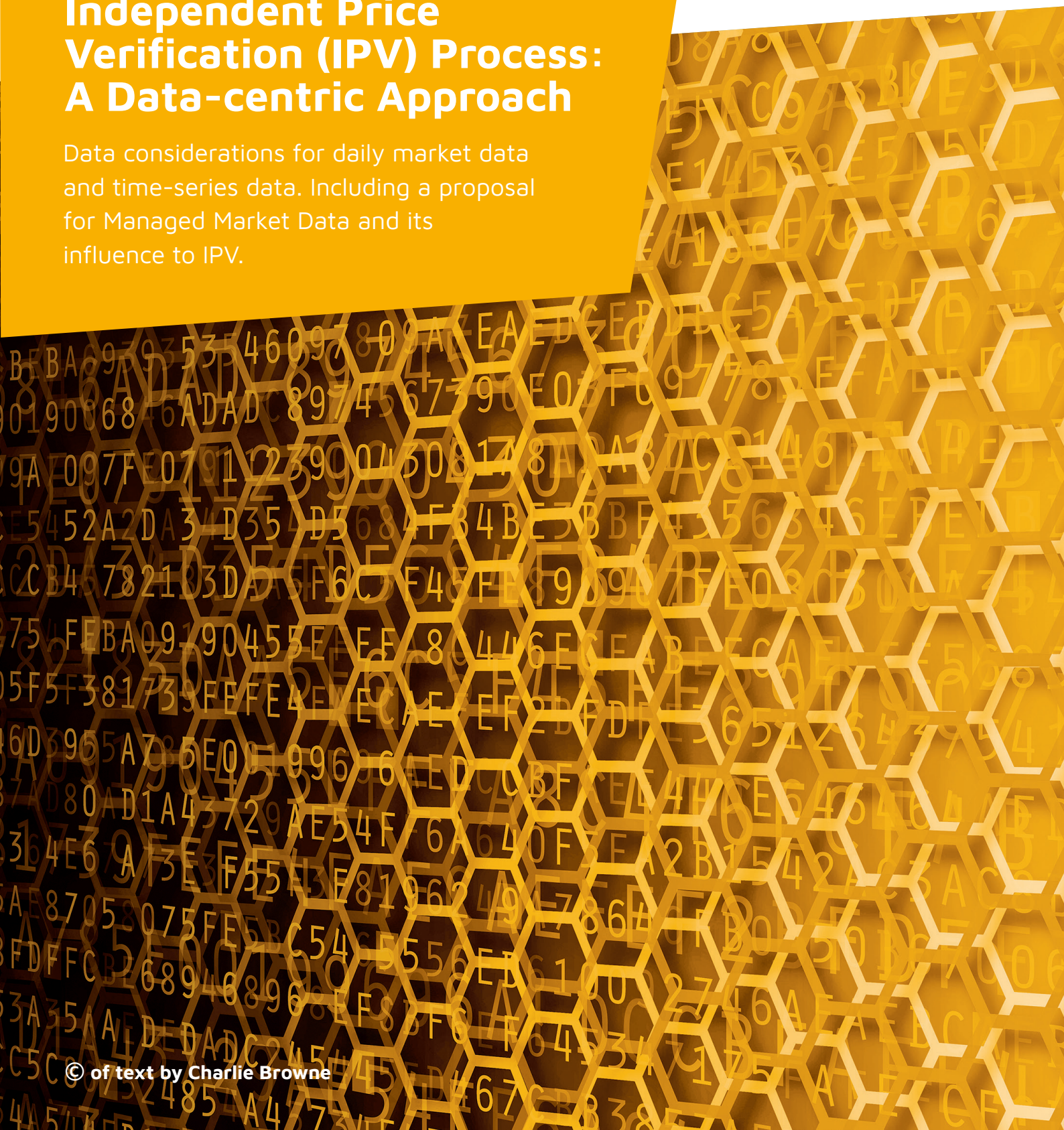
RSU MARKETS

Market Data for the Independent Price Verification (IPV) Process: A Data-centric Approach

Data considerations for daily market data and time-series data. Including a proposal for Managed Market Data and its influence to IPV.



Ensuring the availability and quality of market data is a major challenge for companies in the financial services sector.
In risk assessment, accounting and payment processing, market data is essential to the valuation of financial products.

This white paper covers the topics of independent price verification (IPV) and valuations. It shows how extensive and complex the handling of market data is, especially with regard to the regulatory framework (FRTB).

Procurement and quality assurance take up more than 80% of the work with market data.
When verifying front office prices using independent data sources but also when introducing new financial instruments, the need to have a centralized market data system as a single point of truth becomes apparent. Especially in a rapidly changing market environment, it is necessary to be able to make adjustments to quality assurance algorithms, access new data sources and integrate new products promptly and centrally in order to avoid having different databases with different timelines.

The paper also addresses the issue of volatility surfaces and explains why risk-based views are necessary for managing derivatives market data.

RSU is your reliable partner in market data and risk management: we' ve been delivering risk management solutions to banks and institutional investors for 15 years and have recently expanded into the field of market data.

Our ambition is to deliver top quality with our solution for integrated **market data management and efficient data distribution (MDA)**.

Our centrally operated system supplies quality-assured market data for numerous asset classes, making it the ideal Single Point of Truth for risk management, daily profit and loss calculation, regulatory management and accounting. As of today MDA already computes more than 150,000 financial instruments each day – over 16 million overall so far.

1. Introduction

Market data (both daily and time-series) is an essential element in the production of P&L and risk numbers in firms that are subject to market risk regulatory capital requirements and specifically to those that will need to comply with FRTB. Market data is required to answer all 5 of the key questions that a trading firm needs to answer on a daily basis.

Five Questions for P&L and Market Risk Instruments

Today' s P&L rates ok?
Can I see explain the impact of changes in market rates on today' s P&L valuations?

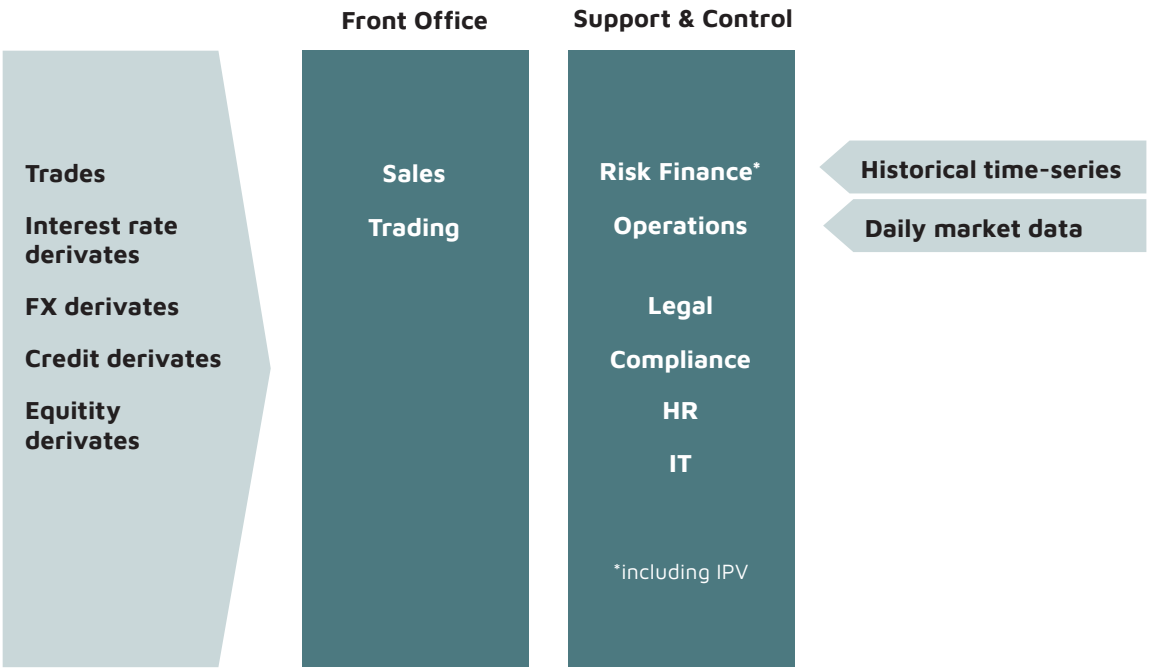
Historical rates ok?
Can I see the time-series & associated validation status for the instrument?

Analytics & Quant Development?
Can I use the validated data to perform analytics & do quantitative development?

Is instrument modellable?
Do I have sufficient real price observations?

Materiality?
Do I have exposures in the instrument?

The interaction between Valuations teams (that often sit within Finance and includes both IPV and PRUVAL teams) and Market Risk teams (that roll up to the Risk function) is a topic that is of crucial importance for both FRTB and for more generally for the efficient operation of the bank' s trading function – which sits and is run from the Front Office.



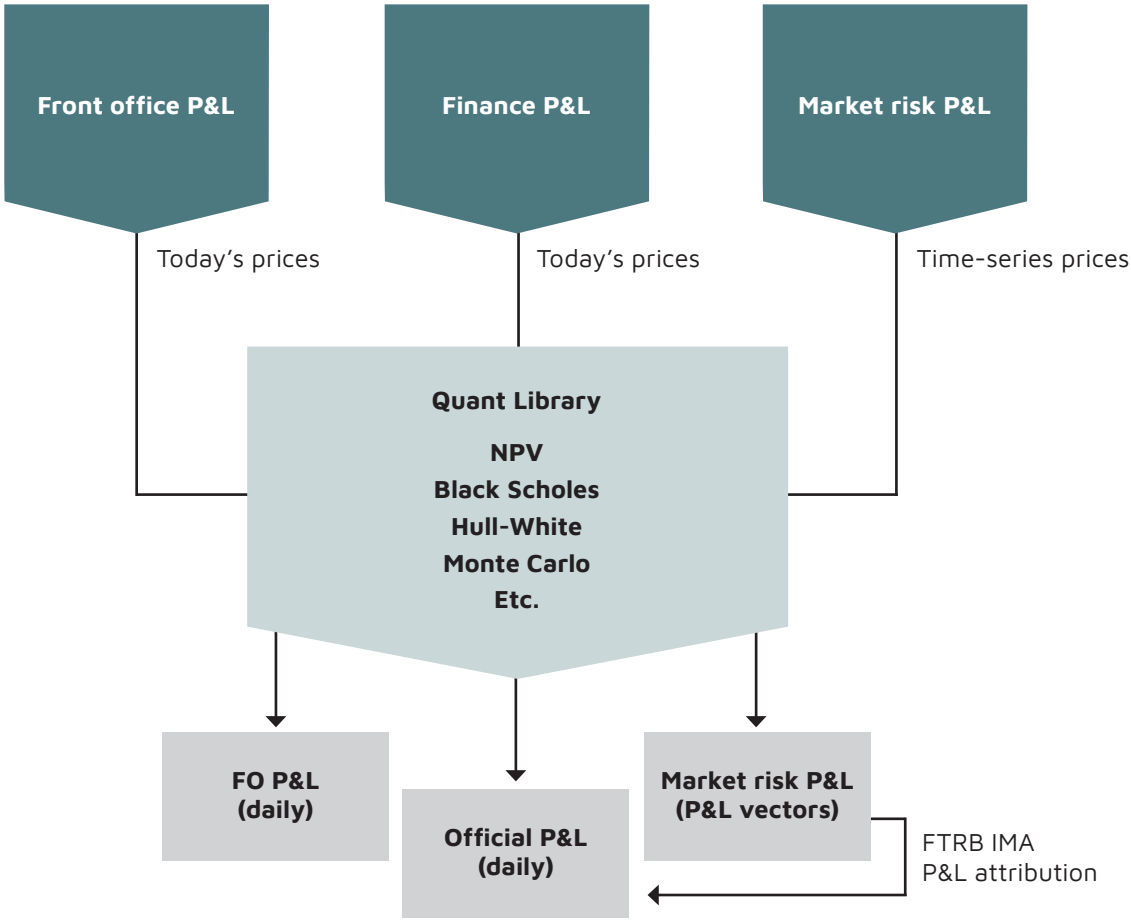
The use of a common database of market data across Finance, Risk and Front office is a basic principle of EDM (Enterprise Data Management) for a trading firm. At its most basic, market data is required to generate valuations (and therefore P&L) and nothing more. Changes in market data over the course of either a day or over a historical time-frame (e.g. a Liquidity Horizon) creates the P&L that the trading function is ultimately striving to produce and report as accurately as possible. One way to think of this is to think about P&L coming in three forms:

- **Front Office P&L** > Daily changes in front office rates
- **Finance P&L** > Daily changes in Finance approved rates
- **Market Risk P&L** > Changes in rates over a specific time-horizon

The diagram below illustrates the concept.

FRTB refers to these historical time horizons as liquidity horizons

The Types of P&L

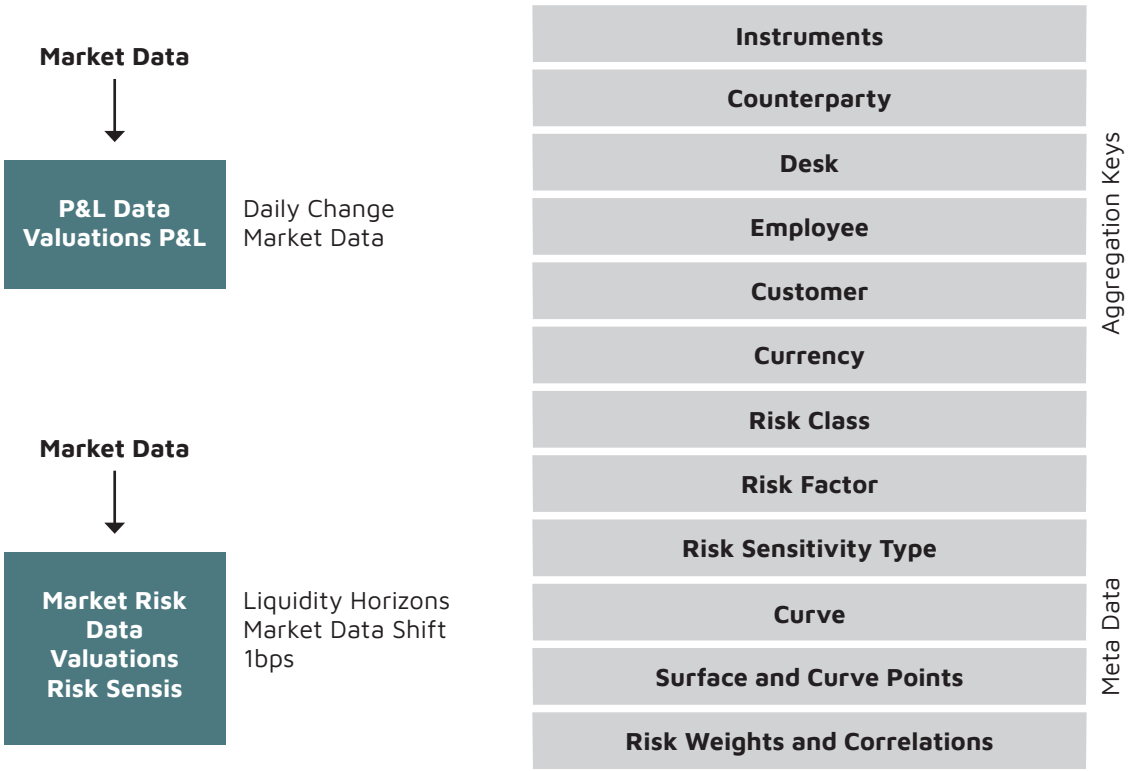


One of the key objectives of FRTB is to ensure that these different categories of P&L are produced in broadly the same way and that any differences between the approaches can be explained. One of the tests that a trading desk needs to be able to pass in order to be allowed use the FRTB Internal Models Approach (IMA) is the P&L Attribution test. The broad objective of this test is to make sure that P&L that is produced for official reporting uses models, data and approaches that are consistent with the models, data and approaches that are required to produce market risk regulatory capital numbers under IMA. To achieve this objective it is essential that both the Valuations teams that sit in Finance and the Market Risk teams are using the same consolidated data stores. The design of relationships between the data stores that exist across Valuations and Market Risk teams will be central to the success of the coordinated approach that regulations such as FRTB demand. If the data stores underlying Finance and Market Risk are aligned and adhere to a robust set of data modelling and lineage principles then the calculations become straight forward. Data and data alignment is 80% of the work. The diagram below illustrates the concept.

Calculations

Expected Shortfall	P&L Attribution	P&L Explain	PRUVAL	Daily P&L	FVA
Value – At – Risk	Risk Weighted Sensitivities	VaR Back Testing	IPV	Bid-Ask Reserves	CVA

Data



2. IPV and Valuations

IPV stands for „Independent Price Verification “. The primary purpose of an IPV team is to ensure that the rates and prices that a Trading Desk uses to generate its version the desk’ s valuations and P&L are independently verified. One of the main tasks that an IPV function is check the validity of the prices that are used by traders to generate their Front Office P&L:

What is an IPV?

”Independent Price Verification“
Compare Font Office Prices to Independently Sourced Prices

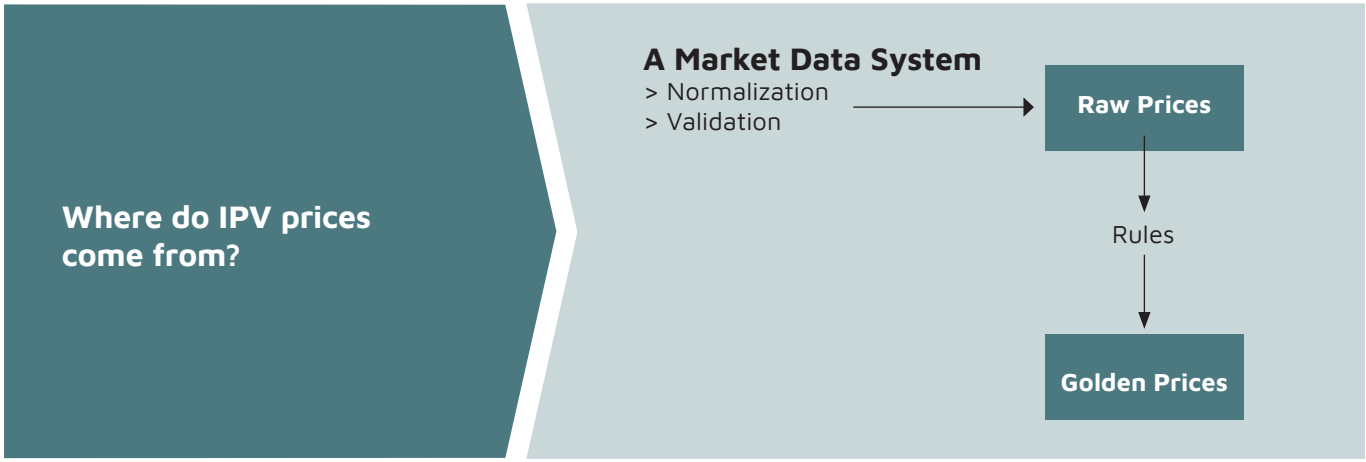
Front Office prices need to be tested. They can come from multiple sources:

Where do Font Office prices come from?

Anywhere
- Traders
- Spreadsheets
- Manual
- Etc

Prices need to be tested

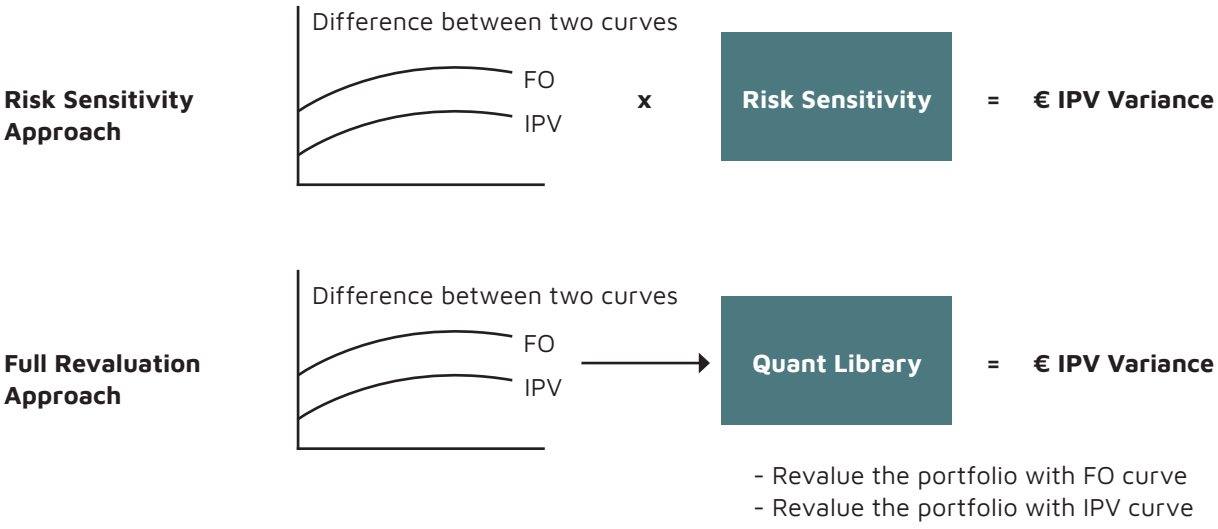
Front Office prices are usually tested by comparing them to independently sourced prices. In our FRTB eco-system, these independent prices are sourced from vendors / other locations, normalized, validated and stored centrally in a Market Data System:



Differences between Front Office and IPV rates lead to a need to make an adjustment to Front Office valuations. These types of adjustment are called IPV Variances. When producing IPV variances for derivative positions, two types of approaches are possible:

- A risk sensitivity approach
- A full revaluation approach

Two approaches to calculating IPV variance

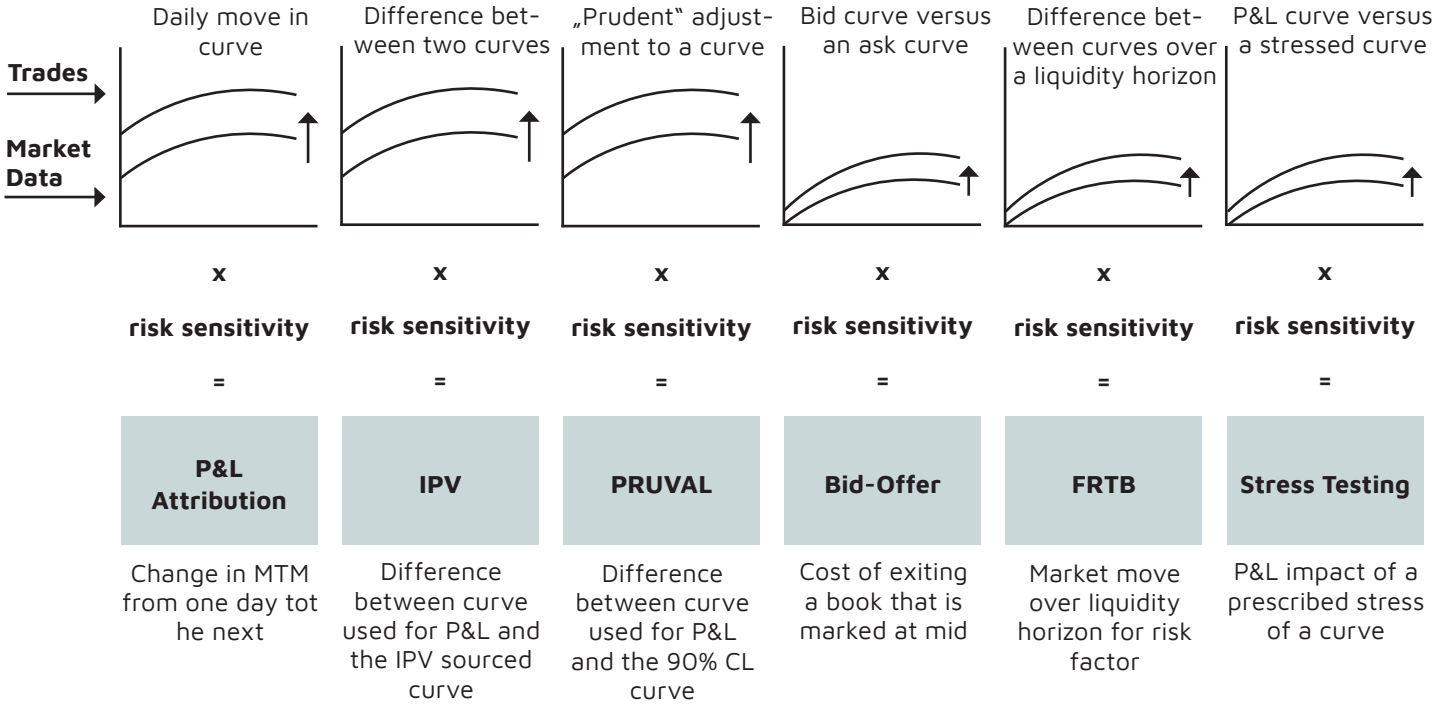


Most Finance and Market Risk calculations (including IPV variances) can be calculated using either approach.

Risk sensitivities are typically produced by the bank' s Quant Library by shifting curves or other risk factors by a standardized market data amount (e.g. a basis point). The risk sensitivity is the difference between the valuation produced before the risk factor shift and the valuation produced after the risk factor shift. The diagram below describes Curve Shift Approaches showing how risk sensitivities can be used to generate the P&L & Market Risk charges including IPV Variances.

GoldenSource `Curve Shift` Methodology

Valuation Engine



Note: A risk sensitivity is a calculation that approximates the P&L of a position or portfolio if a market data input is shifted by a standardized amount (e.g. 1 basis point).

A full revaluation approach does not require risk sensitivities to be produced. It instead takes market data (or risk factor) inputs, applies them to the trades and positions within the portfolio and revalues the entire portfolio using the bank' s quantitative models. Multiple revaluations are required for attribution of P&L to individual risk factors. Full revaluation is a more accurate approach than the risk sensitivity approach. But it is also computationally more expensive, requiring more powerful IT systems to perform the calculations.

2.1 Centralizing and Managing Market Data

A centralized market data system is central to Valuations and IPV. A trading firm need centralized market data if one or more of the following applies:

- market data is stored in multiple disparate locations
- it spends a lot of time manually scrubbing market data
- there is a lack of automated processes for market data
- there is no single source for market data
- there is a need to reduce operational risk associated with market data
- auditors have identified that market processes are ad-hoc
- there is a need to reduce the cost of market data in your firm
- there is a need to reduce the number of market data terminals your firm pays for
- there is a need to view market exceptions using user friendly curves and surfaces
- configurable, out-of-the-box validation rules/tolerance checks are required
- a hierarchy of pricing sources is required

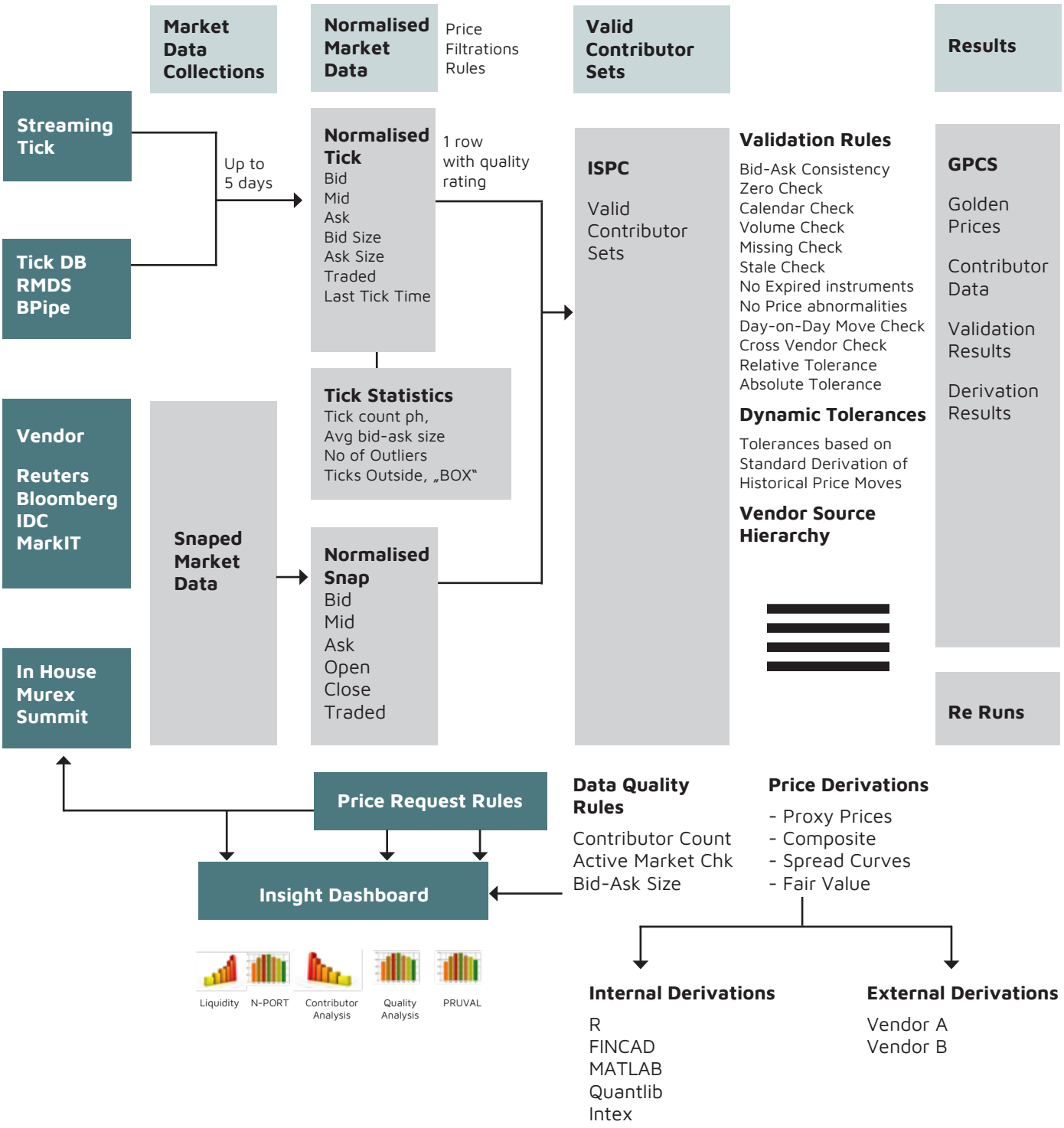
The key requirements in a centralized market data system are:

- It provides a central repository for market data in a firm
- It validates market data in a fully audited system
- It handles EOD and time-series market data
- It generates a “golden price” for each price point
- It allows users to drill from “golden price” through rules to source prices
- It contains analytic tools required to generate proxy and model prices

A comprehensive market data system will comprise of

- **An extensive list of Pricing/Market Data Connections.** The market data solution will typically come with out-of-the-box connections. These are feeds from market data vendors such as Reuters, Bloomberg, ICE Data Services, MarkIT, WM, etc. Market data solution vendors will sometimes offer "connections" services on top of the APIs. These are connections to feeds that the data vendor providers that the market data system vendor will maintain on behalf of the firm. Using a market data system vendor to maintain connections reduces the need for the bank to have teams that update their feeds when data vendors update their interfaces.
- **Price Request rules.** Configurable rules that allows market data to be requested data vendors reducing both market data costs and cost of market data ownership. These rules should optimise the efficiency of market data usage by reducing the amount of calls for prices made to the data vendors. Tracking when requests for prices were made and the ability to analyse these requests is key to any solution
- **Price Normalisation rules.** Rules that support transformation of source market data attributes into standardised fields for use in reports and in application logic. Market data vendors have bespoke field names on the feeds they use in their market data feeds. MDS rules allow these to be normalised into standard fields (Bid, Mid, Ask, High, Low, Traded, Open, Close, etc)
- **Vendor Source Hierarchy.** The Gold copy price generation process should support the use of a vendor source hierarchy (VSH) of price sources at many levels (instrument, instrument type, instrument group). The VSH grid allows banks to create choose a GoldenPrice based on its preferences for market data vendor (e.g. Reuters, Bloomberg, IDC, etc) or price contributor (e.g. ICAP, Tullets, BGC, JPM, HSBC, etc)
- **Daily Market Data Validation rules.** A market data solution should come with out-of-the-box rules for market data validation. Examples are Bid-Ask Consistency, Zero Check, Calendar Check, Volume Check, Missing Check, Stale Check, No Expired instruments, No Price abnormalities, Day-on-Day Move check, Cross Vendor Check, Relative Tolerances, Absolute Tolerances and Tolerances based on Standard Deviation of Historical Price Moves
- **Time-Series Market Data Validation Rules.** A complete market data system needs to be able to import historical time-series data and validate the entire time-series. Validation rules should include checks for zeroes, gaps and statistical
- **Market-aligned exception management screens.** The screens used for managing market data exceptions should allow for the viewing and exception management of market data using screens that can be configured to align with typical market views of curves and surfaces. E.g. source market data, missing prices, golden prices, approved prices can be viewed using a market standard ATM Swaption volatility surfaces
- **Risk-based exception management.** For derivatives market data management, risk-based views of market data should be available. Teams responsible for market data analysis or addressing exceptions should be able to quickly see at which point along a curve the firm has exposures – making for a more efficient market data management process
- **Proxy and Model price derivation rules.** Where market data needs to be derived, price derivation rules should be available to derive proxy prices or calculate model prices where required

The diagram below gives and overview of a typical market data end-to-end solution. The solution should be modularised and fully customisable, with a design that increases user empowerment and reduces cost of ownership. Different banks have different requirements. Most buy-side firms, for example, will not need Price Filtration (Golden Price generation using tick data sources).



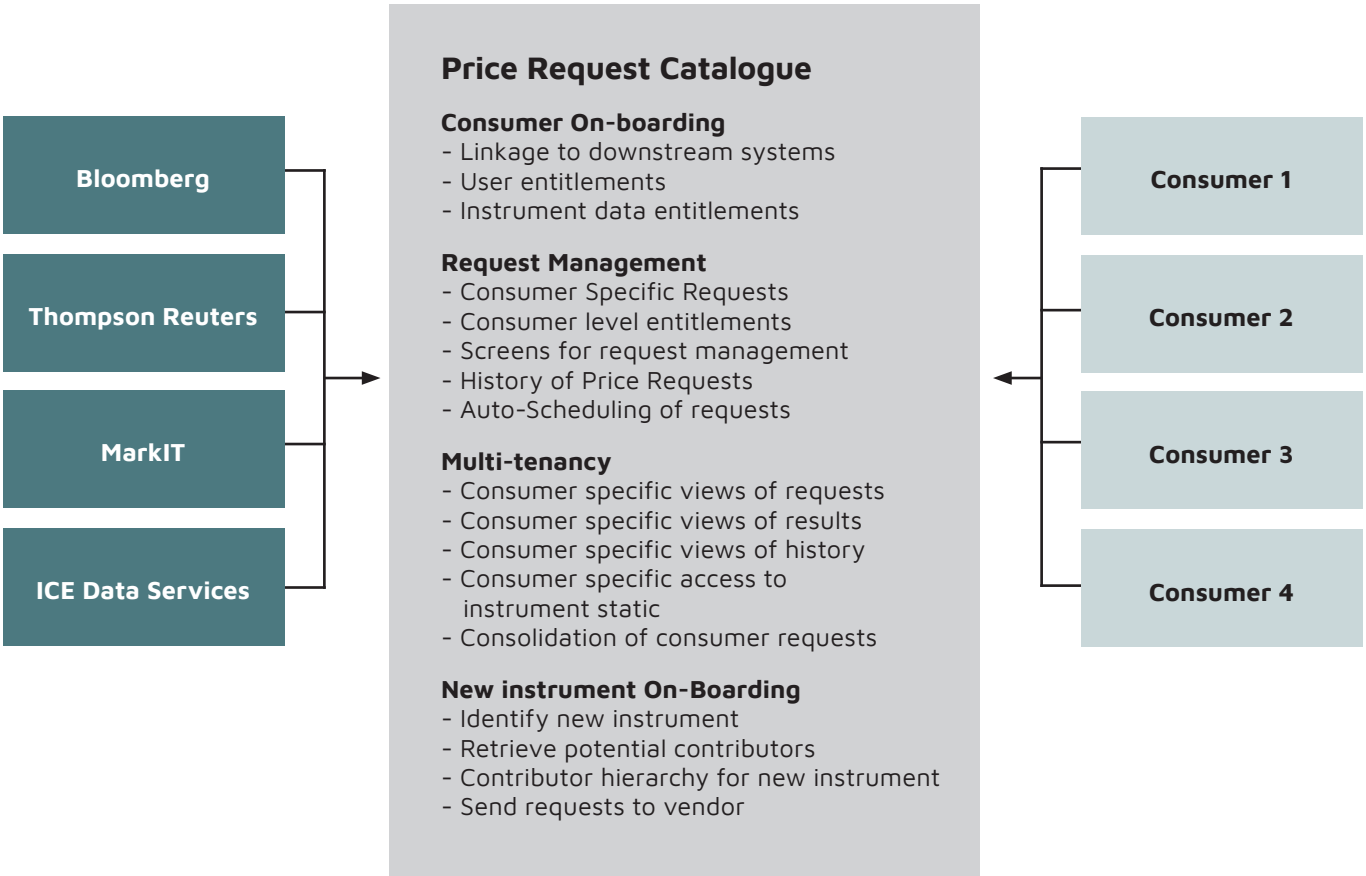
2.1.1. Price Requests

The key requirements for a robust price request process are:

- The optimisation of market data costs
- The ability to on-board new price sources and new instrument types flexibly and quickly
- The automated Price Request hierarchy. The request will move to the next price source in the hierarchy in case of exceptions.
- The integration of the price request process with the late trades process
- If a multi-tenancy solution is required, then
  - Consuming teams need to pay for the market data they use
  - Consumer Price requests should be consolidated so that shared requests are requested only once from market data vendors

The diagram below gives an overview of the basic flow:

- Consumers (teams within the firm) make price requests
- The requests are loaded, consolidated and optimised for vendor market data calls in the Price Request Catalogue
- Where requests for prices for new instruments are made, a new instrument on-boarding is required
- Consumer vendor preferences are maintained within the catalogue



2.1.2. Market Data Collections

The key requirements for a robust market data collection process are:

- The accuracy and quality of market data
- The timeliness of loading and issue resolution
- The flexibility of the exception management screens
- The ability to calculate proxy and model prices
- The ability to normalize the data as part of the loading process
- The standardization of price types, e.g. vendor specific price types might be mapped to a standard set such as:
    - Bid
    - Mid
    - Ask
    - Open
    - Close
    - High
    - Low
    - Traded
    - Model

The following table contains a typical list of vendor sources that might be loaded as part of the market data collection process.

Vendor	Connection	Products
Bloomberg	BO End of Days Pricing	All
	BO Global Commodities	Commodities
	BO Global Commodity Options	Commodity Options
	BO Global Index	
	BO Global Currencies	FX
	BO Equity – MiFID	Equities
	EXT End of Day Pricing Data	All
ICE Data Services	APEX – EOD Listed Pricing	Fixed Income
	APEX – EOD Evaluations Basic Bond Evaluations)	Fixed Income
Thompson Reuters	TR DSE Daily Pricing & Correction, History Service	
	TR DSFI – Bond Pricing Information	Fixed Income
	TR DSS EOD Pricing	All
	TR DSS Intraday Pricing	All
	TR DSS Premium EOD Pricing	All
MarkIT	MarkIT CDS – EOD Composites	CDS
	MarkIT LCDS – EOD Composites	LCDS
SIX	SIX VDF E – Valuation Price data	Fixed Income

2.1.3. Market Data Validations

A market data system needs to be able to validate market data that is loaded into it. The validations need to be instrument level or curve-level depending on the type of validation

A typical set of instrument level validations might be:

- Bid-Ask Consistency
- Zero Check
- Calendar Check
- Volume Check
- Missing Check
- Stale Check
- No Expired instruments
- No Price abnormalities
- Day-on-Day Move check
- Weekly or periodic move check
- Dynamic Tolerances (Standard Deviation Based)
- Cross Vendor Difference Checks
- Relative Tolerances (e.g. percentage moves)
- Absolute Tolerances (e.g. basis point)

Examples of curve level validations, on the other hand, are:

- Curve crossing checks
- Monotonic increasing checks
- Monotonic decreasing checks

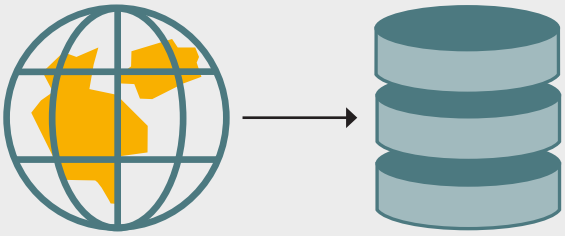
It should also be possible to apply the instrument level validations to all instruments on a curve or volatility surface.

Snapshots & Time Zones

Market data needs to be grouped together in specific narrow time-blocks that are often referred to as snapshots.

The illustration below highlights some of the concepts.

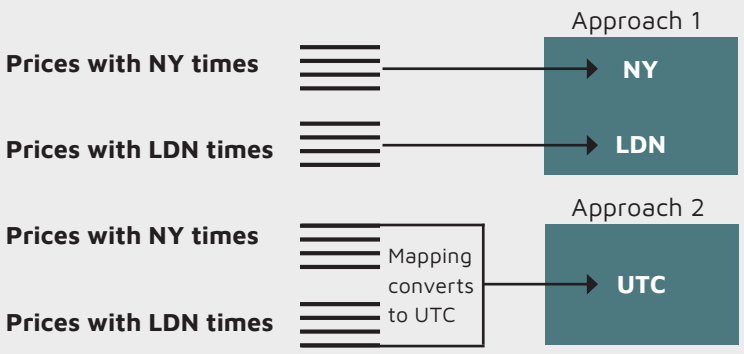
Snapshots & Time Zones
- Snapshot defined as Price Point Events (in PPED table)
- Snapshot identifier passed as a workflow parameter.
- Loading process labels all prices in ISPC with the snapshot identifier
- A Time & A Time Zone can be attached to each Snapshot
- Different Validation rules can be defined for each Snapshot
- Golden Price are generated by Snapshot
- MDS UI selects prices be Snapshot



Snap Time Name	Time	Time Zone	Snap Time Type
GMT1000AM	10:00	GMT	
GMT1500PM	15:00	GMT	
GMT1800PM	18:00	GMT	EOD

Default to Prior Functionality
Default-to-Prior rule can copy forward prices
- Within same snapshot
- From other snapshots

Default-to-Prior rule will only copy forward prices within same Time-Zone



- Separate price data sets per TZ
- Higher number of price inserts
- Global price data set requires merging + copy back to ISPC

- Single database. Single UTC time-zone
- Higher number of price updates
- Automatically delivers global price data set
- Screens will covert screen times for users

2.1.4. Validations & Correction Methods

The types of functions that you would expect Market data validation & correction methods to be able to cover are:

- Instrument Level validations
- Curve level Validations
- Automatic Correction Methods
- Bulk Correction

Some of the detailed calculations that are possible are:

Parameterizable instrument level validation

- DoD movement checks (percentage, absolute, relative, standard deviation)
- Multi-vendor checks
- Zero checks
- Missing checks
- Calendar checks
- Time-range checks
- Stale checks
- Bid-ask checks
- Black-list check list
- Price Age
- Time-series statistical checks
- Price Level

Paremeterizable curve level validations

- All points valid
- All points from same contributor

Automatic Correction methods

- Linear interpolation
- Copy forward
- Gap Filling time-series
  - Returns Methods
  - Proxy Approaches

Bulk Correction Methods

- Suspect-to-Valid
- Prior Day Price

Manual Correction Methods

- Interpolation
- Copy forward
- Proxy methods
- Choose vendor/contributor

2.1.5. The Golden Price Level

When implementing a market data system a fundamental design concept is the level at which golden prices can be created at.
Some sample levels that golden prices can be created are:

- Instrument
- Instrument and currency
- Instrument, currency and market
- Instrument and price type
- Instrument, price
- More granular levels

The most common level that golden prices are created is instrument, currency and market.
The following diagram shows tables for sample levels that golden prices can be created at.

Sample Golden Price Levels

Golden Prices by Instrument

Golden Records

Instrument	Type	UNIT_CPRC	PRC_TYP	Bid	Mid	Ask	Settle	Open	NAV Price
EUR-DEP-EURIBOR3M-1M	Deposit Rate	-0.34	Bid	-0.34	-0.344	-0.348			
EUR-EURIBOR3M-Future 1	Futures Rate	-0.24	Settle				-0.24		
EUR-EURIBOR3M-2Y	Swap Rate	-0.14	Mid	-0.14	-0.144	-0.148			

Golden Prices by Instrument and Price Type

Golden Records

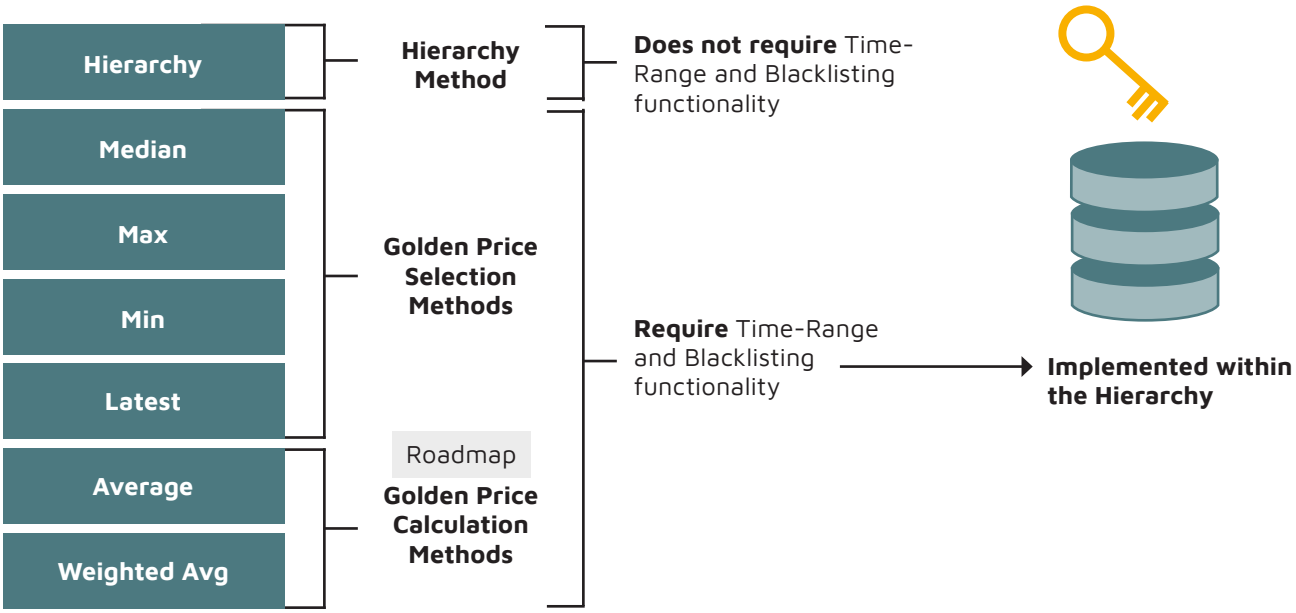
Instrument	Type	UNIT_CPRC	PRC_TYP	Bid	Mid	Ask	Settle	Open	NAV Price
EUR-DEP-EURIBOR3M-1M	Deposit Rate	-0.34	Bid	-0.34	-0.344	-0.348			
EUR-DEP-EURIBOR3M-1M	Deposit Rate	-0.344	Mid	-0.34	-0.344	-0.348			
EUR-DEP-EURIBOR3M-1M	Deposit Rate	-0.348	Ask	-0.34	-0.344	-0.348			
EUR-EURIBOR3M-Future 1	Futures Rate	-0.24	Settle				-0.24		
EUR-EURIBOR3M-2Y	Swap Rate	-0.14	Bid	-0.34	-0.344	-0.348			
EUR-EURIBOR3M-2Y	Swap Rate	-0.144	Mid	-0.34	-0.344	-0.348			
EUR-EURIBOR3M-2Y	Swap Rate	-0.148	Ask	-0.34	-0.344	-0.348			

2.1.6. Golden Price Approaches

Golden prices can be created using different calculation methods. Typical sample methods are:

- Hierarchy-based methods
- Golden Price Selection methods
- Golden Price Calculation methods

The diagram below illustrates the concept.



- Golden Price Selection Methods select existing one-from the existing set of candidate prices to be golden
- Golden Price Calculation methods use the set of candidate prices as input to a golden price calculations

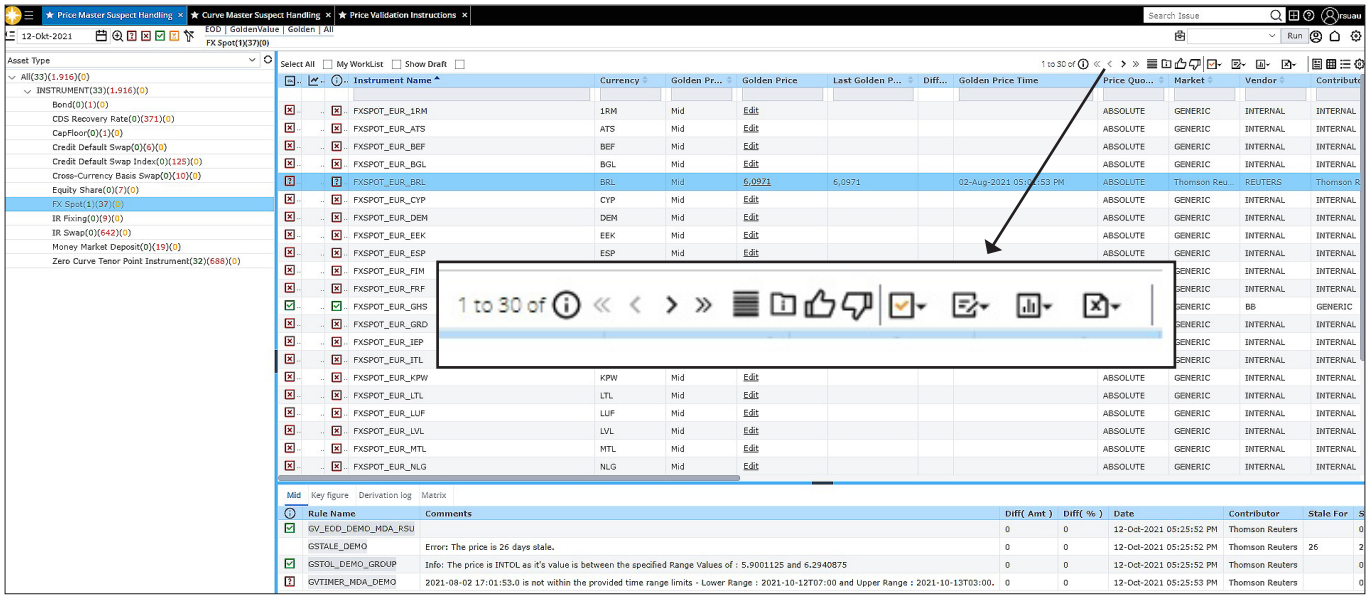
Hierarchy and Selection methods always end up using a source price (e.g. a vendor price) as the golden price whereas golden price calculation methods such as average or weighted average use one or more vendor prices as inputs but golden price that' s created is not a vendor or source price. It is a calculated price.

2.1.7. Managing Market Data Exceptions

When market data is loaded into the market data system and validations have been applied, exceptions will be generated. These exceptions need to be managed in a user-friendly exception management and resolution user interface (UI). The UI should:

- have the ability to drill from gold copy prices back to the source (vendor) prices that were used to generate them
- have single-click issue resolution
- have the concept of suspect, missing or invalid prices
- have 4-eyes review principles built-in for user edit of prices
- allow users to choose different contributor prices as alternative pricing sources
- allow users to see price histories
- allow users to view exceptions using volatility surfaces and curves
- allow users to view and resolve exceptions using either bulk exception screens or more visually oriented exception management screens

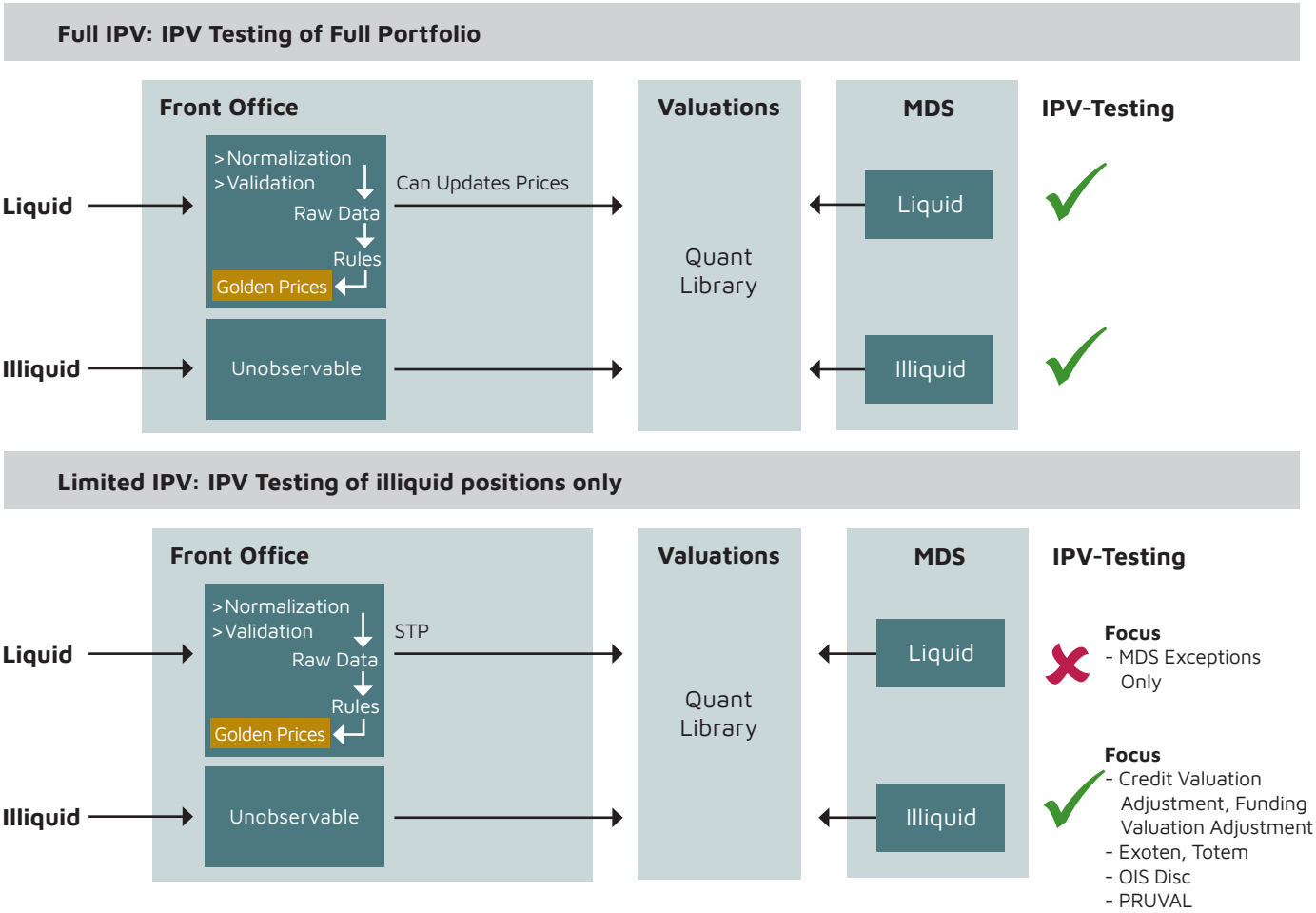
Example: Approving / Rejecting Market Data Exceptions / Amendments in the Bulk Screen



2.2. The scope of IPV

An operating model question that typically arises when it comes to approaches to IPV is whether or not the desk' s entire portfolio of positions needs to be independently tested, i.e. why do Front Office prices need to be tested at all? When marking their positions, why don' t traders just use the same independently sourced prices that the IPV team uses? If they did then there would be no need for the IPV team to test the prices, i.e. if trader prices could be guaranteed to be sourced from independent third parties, then there is no need to compare them again to those same independent prices.

So these two alternative approaches to IPV can be thought of as "Full IPV Testing" and "Limited IPV Testing ". The diagram below illustrates the concept:



Full IPV Testing

- Test the entire portfolio – i.e. test both liquid and illiquid positions

Limited IPV Testing

- Only test the Illiquid positions
- Liquid positions are marked directly in the Front Office using automated feeds of independent prices
- Traders cannot update prices for liquid positions without approval from IPV

As discussed, whether a bank uses the Full IPV Testing approach or a Limited IPV Testing approach is an operating model decision that depends on a number of factors:

- Market data costs
- IT infrastructure
- Centralization of market data processes
- Ability of the desk to implement the required processes

2.3 Valuations and Liquidity

Market liquidity is a market 's ability to purchase or sell an asset without causing a material change in the price of the asset. It describes the asset 's ability to sell quickly without having to reduce its price. Liquidity is about how big the trade-off is between the speed of the sale and the price it can be sold for. In a liquid market, the trade-off is mild: selling quickly will not reduce the price much. In a relatively illiquid market, selling it quickly will require cutting its price by some amount.

The determination of the liquidity of the markets that underlie market data sources is key function that IPV and Valuations Teams perform. Functions such as:

- Fair Value Hierarchy and IFRS13
- Prudential Valuations
- Bid-Ask Reserves (require processes that review and determine the liquidity of the underlying market data)

2.3.1 Anatomy of a Market

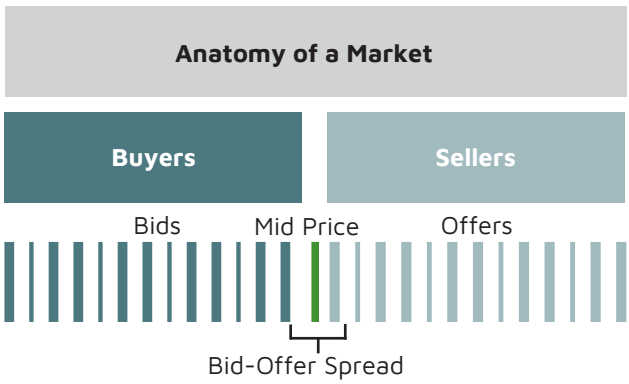
Markets in their purest form are relatively simple constructs. There are buyers, sellers, ask prices, bid prices and a mid-price. There isn' t much more to them than that. Buyers always have to buy at the price the seller is willing to sell at (the ask price). And sellers always have to sell at the price the buyer is willing to buy at (the bid price). These basic concepts apply to anything that is being bought and sold in any market in the world.

Financial markets are like any other market. Exactly the same principles apply as apply for the exchange of goods and services in the rest of the economy. The perceived complexity comes from the fact that in financial markets the products that are being sold are less familiar to people. Exchanging money for widgets in a manufacturing environment is a relatively straight-forward concept. Indeed, exchanging money for a bond or an equity is also a relatively straight-forward concept.

But conceptualizing payment for an OTC (over the counter) derivative that transfers interest rate risk from a fund to an investment bank is more difficult. Or when a pension fund manager transfers 50 year inflation rate risk to an investment bank via an inflation swap, the concepts become that bit harder to grasp. They become harder again to grasp when non-market practitioners realize that the inflation swap is exposed not just to inflation rate risk but also to interest rate risk because the future cash flows generated by the inflation swap need to be discounted with an interest rate curve. Explaining that the interest rate curve that is used to discount the future cash flows of the swap depends on the collateral posted against the swap, can lead to further confusion[2)].

And telling someone who doesn' t have experience with derivatives that the asset manager who needs to post collateral has an option to post dollars, sterling or US Treasuries as the collateral amounts, will likely lead to that final bit of confusion. And if it doesn' t it certainly will when you tell him that the optionality he holds when posting cash or bonds to collateralize to the swap position means he has exposure to volatility rates that need to be derived from the market.

Luckily, none of these concepts need worry the market data practitioner. It helps if he understands them but he doesn' t need to. All he needs to know is the fundamentals of how a market works, i.e. there are buyers, sellers, ask prices, bid prices and a mid-price. These concepts are illustrated using the diagram below.

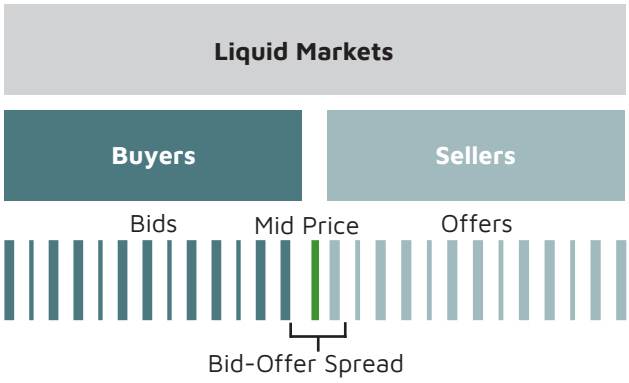


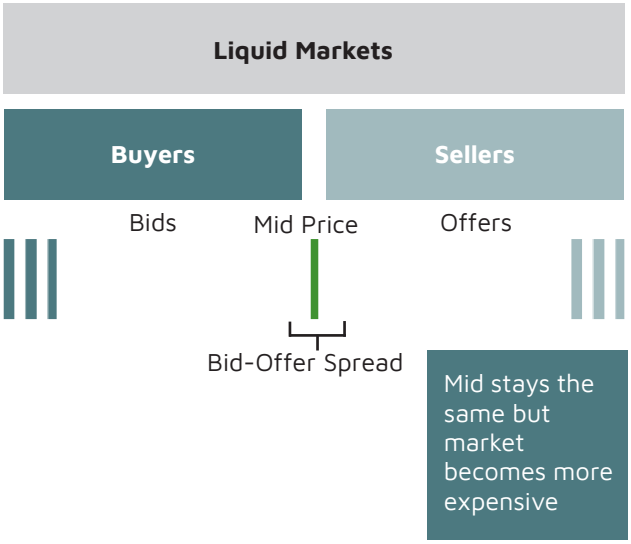
- **Buyers** want to buy at the lowest possible price
  Sellers want to sell at the highest possible price
- **A Trade** occurs when a buyer agrees to a sellers offer price
- Liquidity is a **Pre-Trade** concept, not a post-trade concept
- There is no such things as a **Mid Price** in markets.
  Mid Price is a concept used for valuation purposes.

[2)] A swap that is fully collateralized with margin cash posted on a daily basis should be discounted at the rate of return that the cash would give an investor if he invested it for one day (the overnight rate)

2.3.2 Liquid versus Illiquid Markets

Markets can be liquid or illiquid. If they are liquid, there is lots of trading going on and their bid-offer[3] continuums as illustrated in the diagrams below are crowded, leading to a small gap between the highest bid and the lowest offer. This gap, whether big or small, is called the bid-offer spread. As you can also see from the diagram below, in an illiquid market the bid-offer continuum is typically sparsely populated, leading to a wide bid-offer spread. In illiquid markets, sellers find it hard to sell and buyers find it hard to buy. When bid-offer spreads are wide enough, mid-price valuations become meaningless and large reserves for bid-offer spreads need to be taken on to the firm' s balance sheet.





Liquid → **Less Liquid**

- Short Dated Instruments
- Mature Markets
- Exchange Traded
- G10 Countries

- Long Dated Instruments
- New Markets
- OTC
- Non G10 Countries

Examples

- US Treasures
- Gilts
- Listed Equities
- Interest Rate Futures
- G10 FX

[3] The terms "offer" and "ask" are analogous in the context of financial markets

2.3.3 Liquidity Indicators

There are different ways to measure liquidity. The size of the bid-offer spread, the number of trades or quotes in a given time-period, the length of time it takes to exit a position without moving its price.

The table below provides an overview of the different types of liquidity indicators there are and the regulations that they apply to:

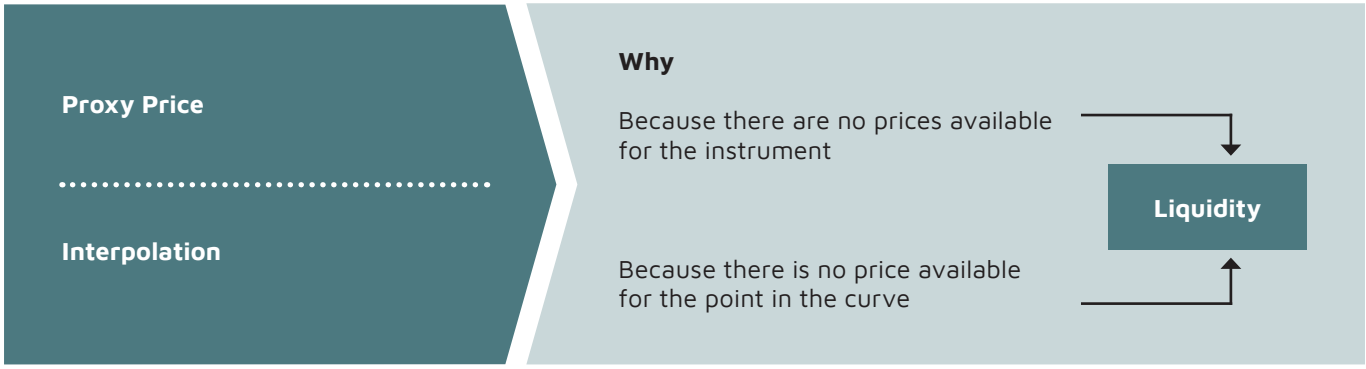
Liquidity Indicator	Related Regulatory Concept
Size of Bid-Offer Spread	N-PORT Bid-Offer Provisioning PRUVAL Close-out Costs AVA
Number of ticks in a time period	N-PORT IFRS13 Level 1/2/3 Classifications
Market Depth Distribution of price sources	PRUVAL Market Price Uncertainty AVA
No of trades in a time period	N-PORT IFRS13 IFRS13 Level 1/2/3 Classifications
Exit Time for a position	PRUVAL Concentration AVA FRTB ES Liquidity Horizon
Liquidity breakdown of fair value balance sheet	N-PORT IFRS13 Level 1/2/3 Classifications

The table below apply describes some of the approaches that can be used with GoldenSource' s Market Data Solution (MDS) to derive liquidity indicators.

Liquidity Indicator	Related Regulatory Concept	MDS Functionality
Size of Bid-Offer Spread	Bid-Offer Provisioning	Price Types in MDS allow bid and ask curves to be created. Risk Sensitivities can be used to calculate required reserve amounts
Number of ticks in a time period		Tick Filtration solution allows snap times to be defined and tick counts per instrument to be calculated
Market Depth Distribution of price sources	PRUVAL Close-out Costs AVA	The standard deviations of the distribution of contributor prices allows a 90% CL MPU AVA to be calculated
No of trades in a time period		(Backward looking view of liquidity). Trade counted by instrument in a given period
Exit Time for a position	PRUVAL Concentration AVA FRTB ES Liquidity Horizon	Bid-offer spreads can be widened if the number of days to exist a position exceeds 10. RiskHub time series of market moves using pre-defined Liquidity Horizons allows market risk capital to be calculated using Expected Shortfall calculations
Asset Class Taxonomy	IFRS13 Level 1/2/3 Fair Value Balance Sheet	Use Issue Types to determine Level 1/2/3 Classification

2.3.4 Proxy Pricing for Illiquid Instruments

Proxy pricing, model pricing and interpolation are methods for deriving prices when there are insufficient bids and asks available in the market to come up with a price that can be used for valuation purposes.



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