



FRTB P&L Attribution Tests and Backtesting

Accelerator Cube Specification and File Format

Version 2.0.0

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1. Document History

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3. Overview

This document describes the implementation of P&L Attribution Tests and Backtesting in the ActiveViam FRTB Accelerator.

3.1 Supported Use Cases

The P&L Attribution Tests and Backtesting have been designed to enable the following use cases.

1. Monitoring historical VaR and P&L values at the desk and firm-wide¹ levels, as required by regulation.
2. Calculating desk and firm-wide VaR values from trade level VaR P&L vectors.
3. Customising² trade level inputs and analytics to support analysing recent exceptions/outliers.

¹ All IMA desks (i.e. excluding SA desks), as per the FAQ: BCBS 395 section 2.7 Q1.

² This use case relies heavily on custom inputs (for example, asset class) beyond what can be included in the Accelerator.

4. Definitions³

- **T-1**: the most recent close of business. This is the **AsOfDate** in the cube.
 - **T-n**: close of business for the nth preceding business day.
 - **Actual P&L [APL]**. As-of T-1, the daily P&L (from T-2 to T-1) of the desk (or firm-wide) based on actual prices⁴ and including trading activity⁵.
 - **Hypothetical P&L [HPL]**. As-of T-1, the daily P&L value (from T-2 to T-1) of the desk (or firm-wide) based on actual prices for the T-2 portfolio⁶.
 - **Risk-Theoretical P&L [RTPL]**. As-of T-1, the daily P&L (from T-2 to T-1) of the desk (or firm-wide) based on model-generated prices for the T-2 portfolio.
 - **VaR measures**. As-of T-1, the model-generated one-day value-at-risk measures for the T-1 portfolio.
 - These measures may be generated from VaR P&L vectors containing the distribution of one-day P&L values (calibrated to the last 12 months of daily market moves), or pre-calculated.
- Note:** the as-of T-1 VaR measures are interpreted as a prediction of P&L for COB T. So, when comparing with the P&L values, the VaR measures need to be shifted by one day.
- **p-values⁷**: As-of T-1, the empirical probability of observing a profit that is less than (or loss greater than) the actual (or hypothetical) P&L⁸.

³ Based on BCBS 352 paragraph 183 and Appendix B; BCBS 395/437 FAQs; and clarifications in BCBS 436.

⁴ From BCBS 352 Appendix B: “the mark-to-market value of the trading desk’s instruments derived from the bank’s pricing models including all risk factors”.

⁵ Excluding fees and commissions.

⁶ Assuming no trading activity (from T-2 to T-1).

⁷ Not required by regulations, but mentioned in BCBS 352 paragraph 182 (b) as something the supervisor may request.

⁸ According to the model

5. Cube Overview

There are two cubes:

- The **PL Summary Cube** for the desk and firm-wide monitoring.
- The **PL Cube** for trade level analytics, including aggregating VaR P&L vectors to the desk level and calculating the VaR values.

The PL Summary Cube:

- Collects aggregated data with a long history (at least the 1 year required by the regulations) at the desk and firm-wide levels. Including:
 - Daily P&L values (actual, hypothetical, and risk-theoretical).
 - Daily VaR values at the 97.5% and 99% confidence level.
- Includes the analytics required for P&L Attribution Tests and Backtesting. Including:
 - The Spearman correlation metric; i.e. the correlation between risk-theoretical P&L and hypothetical P&L.
 - The Kolmogorov-Smirnov test metric, i.e. the similarity of the distributions of risk-theoretical P&L and hypothetical P&L.
 - A count of the number of exceptions when comparing the actual P&L and hypothetical P&L against the VaR at the 97.5% and 99% confidence levels.
 - Underlying measures/partial calculations for the above.

The PL Cube:

- Collects recent data at the trade (or position) level, including the VaR P&L vectors.
- Includes VaR calculations, for calculating the desk and firm-wide VaR values at the 97.5% and 99% confidence level.
- It is expected that this cube will be customised to support analysing exceptions/outliers.

6. PL Summary Cube

The PL Summary cube is aimed at desk and firm-wide monitoring of the P&L Attribution Tests and Backtesting.

It contains aggregated data with at least a year of history including:

- Daily P&L values (actual, hypothetical, and risk-theoretical)
- Daily VaR values at the 97.5% and 99% confidence level.

And can be used to calculate:

- The Spearman correlation coefficient of the two time series rank values of the RTPL and HPL.
- The Kolmogorov-Smirnov test metric, i.e. the largest absolute difference between the cumulative distribution functions for the risk-theoretical P&L and hypothetical P&L..
- The count of the number of exceptions when comparing the Actual P&L and Hypothetical P&L against the VaR at the 97.5% and 99% confidence levels.

With ActiveMonitor, this cube can be customised to add KPIs to monitor the above metrics, and workflows to manage exceptions.

6.1 Input Files

6.1.1 PL_Summary.csv

File pattern match: **PL_Summary*.csv**

This file contains all the data for the PL Summary cube.

Field	Type	Description
AsOfDate	Date [YYYY-MM-DD]	The as-of date (T-1).
Desk ⁹	String	The desk ID, or “All-IMA” for firm-wide.

⁹ The desk is not linked into the desk hierarchy of the other cubes and may actually represent any subset of the data that you wish to monitor.

Currency	String	Currency of P&L and VaR values
Actual PL	Double	Actual P&L value (for desk, as-of T-1)
Hypothetical PL	Double	Hypothetical P&L value (for desk, as-of T-1)
Theoretical PL	Double	Risk-Theoretical P&L value (for desk, as-of T-1)
VaR99	Double	VaR at 99% confidence level (for desk, as-of T-1)
VaR975	Double	VaR at 97.5% confidence level (for desk, as-of T-1)
p-value Actual	Double	(optional) p-value of Actual PL (for desk, as-of T-1)
p-value Hypothetical	Double	(optional) p-value of Hypothetical PL (for desk, as-of T-1)

The key fields for this file are **AsOfDate** and **Desk**.

6.2 Hierarchies

Hierarchy	Level	Comments
Dates (slicing hierarchy)	AsOfDate	The as-of date (T-1). From the AsOfDate field in the input file.
Desks (slicing hierarchy)	Desk	The desk ID. From the Desk field in the input file.
Lookback (analysis hierarchy)	Lookback	The past date. Used for expanding the P&L values for P&L Attribution Test analytics.

6.3 Measures

- Common:
 - **Hypothetical PL:** from input file (after currency conversion).
- For PL Attribution Tests:
 - **Hypothetical PL Lookback:** The Hypothetical PL values expanded along the Lookback analysis hierarchy.
 - **Theoretical PL:** from input file (after currency conversion).
 - **Theoretical PL Lookback:** The Theoretical PL values expanded along the Lookback analysis hierarchy.
 - **Spearman Correlation Metric:** the correlation between RTPL and HPL

- **Kolmogorov-Smirnov Test Metric:** the similarity of the distributions of RTPL and HPL.
- Additional deprecated measures for the BCBS 352 Mean Ratio and Variance Ratio tests (to be removed in a future version).
- For Backtesting:
 - **Actual PL:** from input file (after currency conversion).
 - **VaR 99:** from input file (after currency conversion).
 - **VaR 97.5:** from input file (after currency conversion).
 - **VaR 99 (previous day):** VaR 99 of previous day (T-2)
 - **VaR 97.5 (previous day):** VaR 97.5 of previous day (T-2)
 - **Exception 99 (Actual):** Exception at 99% confidence level for Actual P&L
 - 1 if Actual PL < VaR 99 (previous day);
 - 0 otherwise.
 - **Exception 99 (Hypothetical):** Exception at 99% confidence level for Hypothetical P&L
 - 1 if Hypothetical PL < VaR 99 (previous day);
 - 0 otherwise.
 - **Exception 97.5 (Actual):** Exception at 97.5% confidence level for Actual P&L
 - 1 if Actual PL < VaR 97.5 (previous day);
 - 0 otherwise.
 - **Exception 97.5 (Hypothetical):** Exception at 97.5% confidence level for Hypothetical P&L
 - 1 if Hypothetical PL < VaR 97.5 (previous day);
 - 0 otherwise.
 - **Exception 99:** MAX(Exception 99 (Actual), Exception 99 (Hypothetical)).
 - **Exception 97.5:** MAX(Exception 97.5 (Actual), Exception 97.5 (Hypothetical)).
 - **Exception 99 Count:** The number of Exceptions at the 99% confidence level over the past year.
 - **Exception 97.5 Count:** The number of Exceptions at the 97.5% confidence level over the past year.
 - **Exception 99 Dates:** An array of dates of the Exceptions at the 99% confidence level over the past year.
 - **Exception 97.5 Dates:** An array of dates of the Exceptions at the 97.5% confidence level over the past year.
 - **p-value (Actual):** from input file.
 - **p-value (Hypothetical):** from input file.

6.4 Configuration

6.4.1 Context Values

- **PLALookback** the number of business days to look back when calculating the Spearman correlation and KS test metrics for PLA Tests. This may also be expressed as a period, to look back a number of calendar days, for example, “1M”, “3M”, “1Y”.
- **BackTestingLookback** the number of business days to look back when counting the number of exceptions in the VaR backtesting. This may also be expressed as a period, to look back a number of calendar days, for example, “1M”, “3M”, “1Y”.
- **ReferenceCurrency** the currency the input values are converted to prior to performing all calculations, and the currency used in the output.

7. PL Cube

The PL cube is aimed at calculating desk and firm-wide VaR values from trade level VaR P&L vectors and, with customisation, supporting the analysis of recent exceptions/outliers.

7.1 Input Files

7.1.1 PL_VaR_Vector.csv

File pattern match: **PL_VaR_Vector*.csv**

The VaR P&L vectors

Field	Type	Description
AsOfDate	Date [YYYY-MM-DD]	The as-of date (T-1).
Trade	String	The trade ID (or Position ID for fungible instrument)
Currency	String	Currency of VaR P&L Vector values
PL	Vector	VaR P&L vector (for desk, as-of T-1)

7.1.2 PL_VaR_Scenario.csv

File pattern match: **PL_VaR_Scenario*.csv**

A description of the VaR scenarios.

Field	Type	Description
AsOfDate	Date [YYYY-MM-DD]	The as-of date (T-1).
Index	Unsigned Integer	The index of the VaR scenario (within the VaR P&L vector)
Scenario	String	The name of the VaR scenario

7.1.3 Shared files

The following files are shared with the IMA cube and used to map the trades into the organisation hierarchies.

- Trade_Attributes.csv
- BookParentChild.csv
- LegalEntityParentChild.csv

7.2 Hierarchies

Hierarchy	Level	Comments
Dates (slicing hierarchy)	AsOfDate	The as-of date (T-1). From the AsOfDate field in the VaR P&L Vectors file.
Scenarios (analysis hierarchy)	Scenario	The scenario name. Used for expanding the VaR P&L Vectors.

Additionally, the following organisational hierarchies are shared with the IMA cube:

- **Books**
- **Desks**
- **FRTBModel**
- **Trades**
- **Legal Entities**
- **BookHierarchy**

7.3 Measures

- **VaR PL Vector:** A technical vector-valued measure from the **PL** field in the input files (after currency conversion).
- **VaR PL Expand:** VaR PL Vector expanded along the **Scenario** analysis hierarchy.
- **VaR 99:** The value-at-risk with 99% confidence level¹⁰.
- **VaR 97.5:** The value-at-risk with 97.5% confidence level
- **VaR:** The value-at-risk with the confidence level determined by the **VaRConfidence** context value.

7.4 Configuration

7.4.1 Context Values

- **VaRConfidence** the confidence level used for the **VaR** measure.
- **ReferenceCurrency** the currency the input values are converted to prior to performing all calculations, and the currency used in the output.

¹⁰ Calculated by taking the quantile of the VaR PL Vector

8. Future Accelerator Development

The following features are under consideration for future development in the Accelerator.

8.1 Trade Level Actual P&L and Theoretical P&L Values

Support collecting the trade level Actual P&L and Theoretical P&L values in the **PL Cube**.

Inputs: TBD

The following measures will be added:

- **Actual PL:** Actual P&L value.
- **Theoretical PL:** Theoretical P&L value.
- **p-value (Actual):** quantile of Actual PL in VaR PL Vector (previous day) (TO BE CONFIRMED)
- **p-value (Hypothetical):** quantile of Hypothetical PL in VaR PL Vector (previous day) (TO BE CONFIRMED)

Additionally, the Exception measures can now be copied from the PL Summary cube to the PL Cube.

8.2 VaR P&L Vectors in the PL Summary Cube

Add flexibility to the PL Summary Cube by replacing the VaR inputs with aggregate VaR P&L vectors; and copy the VaR measures from the PL cube. Replace the existing Desks hierarchy with the organisation hierarchies currently present in the IMA (and PL) cubes.