ActiveViam

Interpretation and Implementation of BCBS 457 - SBM Crypto 2a

Atoti FRTB

6.0

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Crypto 2a

This section describes how the SBM Crypto 2a Risk Class is implemented and how the SCO60 specification is interpreted.

There are two configuration parameter, set to false by default, specifically added for the Crypto 2a Risk Class that control specific aspects of its implementation. These are:

- 'frtb.crypto-2a.apply-correlation-stress' detailed in Crypto 2a Interpretation note
- 'frtb.crypto-2a.exchange-stored' explained in UnderlyingDescription

Also covered here is the specialization of the data, calculations, and configuration for the Crypto 2a risk-class, including:

- The data model, which describes the data used for the calculations and how it is structured, and how the data model is represented in the:
  - input files
  - datastore
  - cube
- The calculations, both in the ETL and at query time
- The parameters used in the query time calculations

Interpretation Note

Correlation stress scenario

The specifications are ambiguous about whether the correlations for Crypto 2a defined in [SCO60.76] are subject to the 'high', 'medium' and 'low' scenarios as set out in [MAR21.6] for all other risk classes. The behaviour can be controlled by the 'frtb.crypto-2a.apply-correlation-stress' configuration parameter as follows.

Ignore correlation stressing

This is the default behaviour. The stress scenarios are ignored, and we use the same correlation constants for the 'high', 'medium' and 'low' scenarios. The configuration parameter 'frtb.crypto-2a.apply-correlation-stress' is set to 'frtb.crypto-2a.apply-correlation-stress=false'.

Apply correlation stressing

The correlations for the 'high', 'medium' and 'low' scenarios are calculated in alignment with [MAR21.6]. The configuration parameter 'frtb.crypto-2a.apply-correlation-stress' is set to 'frtb.crypto-2a.apply-correlation-stress=true'.

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Data Model (Core)

This section describes the data used for the Crypto 2a calculations, including how the data is structured.

For Crypto 2a delta and curvature, the **Crypto asset and exchange** (Underlying) refers to the distinct crypto asset [SCO60.73] and the corresponding exchange [SCO60.74].
For Crypto 2a vega, the **Crypto asset** (Underlying) refers to the distinct crypto asset [SCO60.73] without any differentiation by the exchange [SCO60.75].

The **Risk Factor** is used to identify sensitivities. However, it is not used directly in the calculations. Instead, the **Underlying** (generated from the **Bucket** and the **Location** for delta and curvature, and from the **Bucket** alone for vega) and tenor fields are used (as appropriate for the risk-measure). This means that multiple **Risk Factor Names** may be used for the same risk-factor.

Sensitivities

Field	Key	Risk Measure	Description
As-of Date	Y	All	Timestamp (at close of business) for the data (T-1)
Trade ID	Y	All	A unique identifier for the trade (or position)
Risk Factor Name	Y	All	A unique identifier for the risk-factor
Risk Class	Y	All	“Crypto 2a”
Risk Measure	Y	All	“Delta”, “Vega”, or “Curvature”
Sensitivity Tenor	Y	Delta	The time to maturity of the traded instrument
Option Maturity	Y	Vega	The maturity of the option
Sensitivity		Delta & Vega	The sensitivity value s_k
Shock Up/Down		Curvature	The up and down shocked prices.
Sensitivity Currency		All	Currency in which the sensitivity or shocked price is expressed.
Risk Weight		Curvature	Risk weight used for the shocked prices
PV Applied		Curvature	Has the PV been subtracted from the shocked prices?

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Field	Key	Risk Measure	Description
Optionality		Delta	Should the Delta sensitivity be included in the Curvature Calculation?
Interpolated Sensitivities		Delta & Vega	Sensitivities interpolated to the prescribed vertices

Risk Factor: [SCO60.73] to [SCO60.75]

The **Risk Factor** is used to identify sensitivities. However, it is not used directly in the calculations. Instead, the **Underlying** (generated from the **Bucket** and the **Location** for delta and curvature, and from the **Bucket** alone for vega) and tenor fields are used (as appropriate for the risk-measure). This means that multiple **Risk Factor Names** may be used for the same risk-factor.

For Crypto 2a delta and curvature, the **Crypto asset and exchange** (Underlying) refers to the distinct crypto asset [SCO60.73] and the corresponding exchange [SCO60.74].
For Crypto 2a vega, the **Crypto asset** (Underlying) refers to the distinct crypto asset [SCO60.73] without any differentiation by the exchange [SCO60.75].

Field	Key	Risk Measure	Description
As-of Date	Y	All	Timestamp (at close of business) for the data (T-1)
Risk Factor Name	Y	All	A name for the risk-factor
Risk Class	Y	All	“Crypto 2a”
Risk Measure	Y	All	“Delta”, “Vega”, or “Curvature”
Sensitivity Tenor		Delta	The time to maturity of the traded instrument (Delta)
Option Maturity		Vega	The maturity of the option (Vega)
Underlying		Delta/Curvature	The crypto asset and exchange
Underlying		Vega	The crypto asset

For Curvature, the risk-factor is the same as the underlying.

Underlying

For Crypto 2a delta and curvature, the **Crypto asset and exchange** (Underlying) refers to the distinct

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crypto asset [SCO60.73] and the corresponding exchange [SCO60.74].
For Crypto 2a vega, the **Crypto asset** (Underlying) refers to the distinct crypto asset [SCO60.73] without any differentiation by the exchange [SCO60.75].

Field	Key	Risk Measure	Description
As-of Date	Y	All	Timestamp (at close of business) for the data (T-1)
Underlying	Y	Delta/Curvature	Crypto asset and exchange
Underlying	Y	Vega	Crypto asset
Risk Class	Y	All	“Crypto 2a”
Bucket		All	Crypto asset
Location		Delta/Curvature	Crypto exchange

Calculations

This section describes ETL from the reference implementation and the transformations / calculations applied to the sensitivities in the post-processors after they have been aggregated.

First, the ETL (Extract, Transform, Load) layer will apply some transformations as the data is loaded from the input files into the datastore.

Once the data is loaded into the datastore, it is available in the cube. The sensitivities in the cube may be partially aggregated upon commit to the datastore for BITMAP and LEAF aggregate providers. The remainder of the sensitivity aggregation is performed by Atoti Server at query time.

Then, also at query time, the post-processors calculate the capital charge from the aggregated sensitivities.

ETL (Reference Implementation)

The ETL (Extract, Transform, Load) layer provided with Atoti FRTB, using the default file format, will perform the following transformations when data is loaded from the input files into the datastore.

Risk Factor Name

If the risk-factor name is not included in the input file (using the default file format), a name is generated as follows:

- Delta: Bucket + Location
- Vega: Bucket

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- Curvature: Bucket + Location

Normalization

In the default file format, each row of the sensitivities' files contains the sensitivity as well as a description of the risk factor. The data normalization splits this information across two stores in the datastore, as described in the data model.

Vectorization

For efficiency, Delta and Vega sensitivities are stored in vectors. The entries of the vectors represent the tenors/maturities of the risk factors.

In the default file format, we allow sensitivities to be provided as either single values or as vectors. During the ETL, sensitivities are grouped together into vectors.

Interpolation

For compatibility with risk engines, Delta and Vega sensitivities may be loaded for any tenor/maturity. During the ETL, these sensitivities are interpolated to match the tenors/maturities in the specification.

Query Time (Core)

For the Crypto 2a risk class, there are three main chains of post-processor calculations: Delta, Vega, and Curvature.

Delta and Vega

The calculation steps for Delta and Vega are the same:

1. The calculations start by applying currency conversion to the aggregated raw sensitivities from the cube to get the Sensitivities.
2. The risk-weights are applied to get the Weighted Sensitivities (per risk-factor).
3. The (rho) correlations are then used to calculate the Risk Position (per bucket).
4. The Risk Positions are combined across all buckets to calculate the Risk Charge.

In the bookmarks folder "ActiveViam FRTB" -> "Basel Framework" -> "SBM", the bookmarks "Crypto 2a Delta" and "Crypto 2a Vega" contain tabs that walk through these calculation steps and include the measures mentioned here.

Curvature

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For Curvature, the calculation steps are:

1. Start with vectors of shocked prices indexed by risk-weight (per risk-factor).
2. The risk-weight then determines which Shock Up/Down Prices we want, subtracting the trade **PV** if necessary.
3. The delta sensitivities are filtered sensitivities from the Delta calculations, and aggregated per Curvature risk-factor.
4. These are then combined to calculate the CVR Up/Down (per risk-factor).
5. The Risk Position Up/Down are calculated per bucket.
6. The greater of the up and down risk-positions is identified by the Risk Position Scenario, and used for the Risk Position (per bucket).
7. The Risk Positions are combined across all buckets to calculate the Risk Charge.

The bookmark “ActiveViam FRTB” -> “Basel Framework” -> “SBM” -> “Crypto 2a Curvature” contains tabs that walk through these calculation steps and includes the measures mentioned here.

Delta/Vega Sensitivities

The **Delta**/**Vega** **Sensitivities** measures are the s_k in [SCO60.71] and [SCO60.72].

For each **Sensitivity Currency**, the **Interpolated Sensitivities** are converted to the reference currency using the IFxRates API (supplied by the reference implementation). After this currency conversion, the values are aggregated for each **Risk Factor**.

Delta Sensitivities Long/Short

The **Delta Sensitivities Long/Short** measures are the Positive or Negative **Delta Sensitivities**.

The Positive or Negative determination is made at the **Underlying** and **Tenor** levels.

Curvature Scenario Up/Down PV.CCY

The **Scenario Up/Down PV.CCY** measures are vectors of shocked prices indexed by risk weight.

For each **Sensitivity Currency**, the **Shock Up/Down** prices are converted to the reference currency using the IFxRates API. After this currency conversion, the values are aggregated for each **Risk Factor**.

Delta/Vega/Curvature Risk Weight

The **Delta**/**Vega**/**Curvature** **Risk Weight** measures are RW_k in [MAR21.4](3) and $RW_k^{(Curvature)}$ in [MAR21.5](2)(e).

The risk weights are constant for all risk factors as set out in [SCO60.73] for Delta and Vega, and in [SCO60.79] for Curvature.

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Delta/Vega Weighted Sensitivities

The **Delta/Vega Weighted Sensitivities** measures are ws_k in [MAR21.4](3).

For each **Risk Factor** k, the **Delta/Vega Sensitivities** measures are multiplied by the **Delta/Vega Risk Weight**.

Curvature Delta Sensitivities

The **Curvature Delta Sensitivities** measure is defined in [SCO60.79].

For each Curvature **Risk Factor** k, it is all the **Delta Sensitivities** with the same **Underlying** as the risk factor, filtered by **Optionality**.

Curvature Shock Up/Down Prices

The **Curvature shock-up/down prices** measures are $V_i\left(x_k^{RW^{(Curvature)}\pm}\right) - V_i\left(x_k\right)$ in [MAR21.5](2).

Using linear interpolation, the shocked prices corresponding to the **Curvature Risk Weight** are determined from the **Curvature Scenario UP/Down.CCY** vectors. And, if **PV Applied** is not true/yes, the trade **PV** is subtracted.

Curvature CVR

The Curvature CVR measure will take the value of the Curvature CVR Up or Curvature CVR Down depending on the Curvature Risk Position Scenario evaluated at the Bucket level.

This measure will use the Curvature Bucket Scenario to evaluate the Curvature **Risk Position Scenario** at the **Bucket** level.

Curvature CVR Up/Down

The **Curvature CVR Up/Down** measures are $CVR_k^{\pm}$ in **[MAR21.5]**(2).

The **Curvature Delta Sensitivities** are multiplied by the **Curvature Risk Weight** and subtracted from/added to the **Curvature Shocked Up/Down Prices** (respectively).

Delta/Vega Risk Position Double Sums

The **Delta/Vega Risk Position Double Sums** measures are the $\sum_k \sum_l WS_k \cdot WS_l$ intermediate values.

Within each **Bucket**, each pair of **Risk Factors**, is categorised according to:

- Delta
    - Same or different **Risk Factor**
- Vega

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- Same or different **Risk Factor**

Within each category, the pairs of **Delta/Vega Weighted Sensitivities** are multiplied together and summed.

Delta/Vega Risk Position Correlations

The **Delta/Vega Risk Position Correlation** measures are ρ_{kl} in [SCO60.77].

Within each **Bucket**, and for each **Risk Factor** pairs, the value is looked up from the configuration for [SCO60.76].

Delta Vega Risk Position

The **Delta/Vega Risk Position** measures are K_b in [SCO60.77].

For each **Bucket**, the **Delta/Vega Risk Position** is calculated from the **Delta/Vega Weighted Sensitivities** and **Delta/Vega Risk Position Correlations** using the formula in [SCO60.77].

Curvature Bucket Scenario

The Curvature Bucket Scenario measure will always take the value of the Curvature Risk Position Scenario at the Bucket level.

Curvature Risk Position Up/Down

The **Curvature Risk Position Up/Down** measures are $K_b^{\pm}$ in [SCO60.80].

Within each **Bucket**, the **Curvature CVR Up/Down** values are combined using the formula in [SCO60.80].

Curvature Risk Position Scenario

Within each **Bucket**, the **Curvature Risk Position Scenario** measure identifies which of the **Curvature Risk Position Up** and **Curvature Risk Position Down** values is the greater.

Curvature Risk Position

The **Curvature Risk Position** measure is K_b in [SCO60.80].

Within each **Bucket**, it is the greater of the **Curvature Risk Position Up** and **Curvature Risk Position Down** values.

Delta/Vega Risk Charge

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The **Delta**/**Vega** **Risk Charge** measures are defined in [SCO60.78].

They are calculated by summing the **Delta/Vega Risk Positions** over all **Buckets** according to [SCO60.78].

Curvature Risk Charge

The **Curvature Risk Charge** measure is defined in [SCO60.81].

It is calculated by summing the **Curvature Risk Positions** over all **Buckets** according to [SCO60.81].

Input Files (Reference Implementation)

This section describes how the input files containing the sensitivities and mappings are used for the Crypto 2a risk class

The sensitivities are loaded from the Delta, Vega, Curvature sensitivity files.

SBM_Delta_Sensitivities*.csv

The Delta Sensitivity Data is loaded from the **Delta** files.

The following table lists the fields in the file format that is used for the Crypto 2a risk-class. See the Delta file format documentation for details on the file format. See Data Model (Core) for a description of the data model.

Data Model Field	File Column	Notes
As-Of Date	AsOfDate	
Trade ID	TradeID	
Sensitivity Currency	DeltaCcy	
Sensitivities	DeltaSensitivities	May be single value or vector, with the same number of entries as Tenors.
Risk Class	RiskClass	“Crypto 2a”
Sensitivity Tenor	SensitivityDates	May be single value, vector, or empty. If empty, treated as the prescribed tenors: 0;0.25;0.5;1;2;3;5;10;15;20;30.
Risk Factor Name	RiskFactor	(Optional) If not present, generated during ETL.

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Data Model Field	File Column	Notes
Underlying	Underlying	(Optional) If not present, generated during ETL.
Bucket	Bucket	Crypto asset
Location	Exchange	Crypto exchange
Optionality	Optionality	Should this sensitivity be included in the Curvature calculations ('Y') or not ('N')?

SBM_Vega_Sensitivities*.csv

The Vega Sensitivity Data is loaded from the **Vega** files.

The following table lists the fields in the file format that is used for the Crypto 2a risk-class. See the Vega file format documentation for details on the file format. See Data Model (Core) for a description of the data model.

Data Model Field	File Column	Notes
As-Of Date	AsOfDate	
Trade ID	TradeID	
Risk Class	RiskClass	"Crypto 2a"
Option Maturity	OptionMaturity	May be single value, vector, or empty. If empty, treated as the prescribed maturities: 0.5;1;3;5;10.
Sensitivities	VegaSensitivities	May be single value or vector, with the same number of entries as maturities.
Sensitivity Currency	VegaCcy	
Risk Factor Name	RiskFactor	(Optional) If not present, generated during ETL.
Underlying	Underlying	(Optional) If not present, generated during ETL.
Bucket	Bucket	Crypto asset

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SBM_Curvature_Sensitivities*.csv

The Curvature Sensitivity Data is loaded from the **Curvature** files.

The following table lists the fields in the file format that are used for the Crypto 2a risk-class. See the Curvature file format documentation for details on the file format. See Data Model (Core) for a description of the data model.

Data Model Field	File Column	Notes
As-Of Date	AsOfDate	
Trade ID	TradeID	
Risk Class	RiskClass	"Crypto 2a"
Risk Factor Name	RiskFactor	(Optional) If not present, generated during ETL.
Shock Up	Shift_Up_PV	
Shock Down	Shift_Down_PV	
Sensitivity Currency	CurvatureCcy	
Risk Weight	RiskWeight	(Optional)
PV Applied	PV Applied	Has the Trade PV already been subtracted from the shocked PVs ('Y') or not ('N')?
Underlying	Underlying	(Optional) If not present, generated during ETL.
Bucket	Bucket	Crypto asset
Location	Exchange	Crypto exchange

Datastore (Reference Implementation)

This section describes how the SA datastore schema is used for the Crypto 2a risk class.

The schema starts with the SaSensitivities store, which is an index of all the facts in the SA Cube. The **SaSensitivities** store has references to the risk-factor descriptions and sensitivities.

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Risk Factor Descriptions

The risk-factor description starts with the RiskFactorDescription store, which contains the description of risk-factor independent of the Crypto 2a underlying, and a reference to the UnderlyingDescription store for a description of the underlying.

Sensitivities

The sensitivities stores contain the sensitivity values, they are referenced from the **SaSensitivities** store.

Risk Measure	Sensitivity Store
Delta	Delta
Vega	Vega
Curvature	Curvature

SaSensitivities

The **SaSensitivities** store is the base store in the SA Cube Schema. Each row in this table represents a fact in the SA Cube.

The following table lists the fields in the store that are used for the Crypto 2a risk-class. See the SaSensitivities store documentation for details on the store. See Data Model (Core) for a description of the data model.

Data Model Field	Store Field	Notes
As-Of Date	AsOfDate	
Trade ID	TradeId	
Risk Factor Name	Risk Factor	
Risk Class	RiskClass	“Crypto 2a”
Risk Measure	Risk Measure	“Delta”, “Vega”, or “Curvature”

RiskFactorDescription

The RiskFactorDescription store contains the description of risk-factor.

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The following table lists the fields in the store that are used for the Crypto 2a risk-class. See the RiskFactorDescription store documentation for details on the store.

Data Model Field	Store Field	Notes
As-Of Date	AsOfDate	
Risk Factor Name	Risk Factor	
Risk Class	RiskClass	“Crypto 2a”
Risk Measure	Risk Measure	“Delta”, “Vega”, or “Curvature”
Underlying	Underlying	
Sensitivity Tenors	Maturity	for Vega only

UnderlyingDescription

The **UnderlyingDescription** store contains the description of the Crypto 2a underlying.

The following table lists the fields in the store that are used for the Crypto 2a risk-class. See the UnderlyingDescription store documentation for details on the store.

Data Model Field	Store Field	Notes
As-Of Date	AsOfDate	
Underlying	Underlying	
Risk Class	RiskClass	“Crypto 2a”
Bucket	Bucket	Crypto asset
Location	Crypto2aExchange	For delta and curvature only

Note:

Crypto2aExchange is an optional datastore field, which is not required by the calculations. It is disabled by default, in which case the exchange is not stored in the datastore explicitly, however it is still used during the ETL to populate the Underlying and Risk Factor values.

To enable the addition of the optional Crypto2aExchange field in the **UnderlyingDescription** store, the configuration parameter ‘frtb.crypto-2a.exchange-stored=true’ needs to be added.

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Delta

The **SaSensitivities** store contains the Delta sensitivities.

The following table lists the fields in the store that are used for the Crypto 2a risk-class. See the SaSensitivities store documentation for details on the store.

Data Model Field	Store Field	Notes
As-Of Date	AsOfDate	
Trade ID	TradeId	
Risk Factor Name	Risk Factor	
Risk Class	RiskClass	“Crypto 2a”
Risk Measure	Risk Measure	“Delta”
Sensitivity Currency	Ccy	
Sensitivities	DeltaSensitivities	
Optionality	Optionality	‘Y’ or ‘N’

Vega

The **SaSensitivities** store contains the Vega sensitivities.

The following table lists the fields in the store that are used for the Crypto 2a risk-class. See the SaSensitivities store documentation for details on the store.

Data Model Field	Store Field	Notes
As-Of Date	AsOfDate	
Trade ID	TradeId	
Risk Factor Name	Risk Factor	
Risk Class	RiskClass	“Crypto 2a”
Risk Measure	Risk Measure	“Vega”
Sensitivity Currency	Ccy	

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Data Model Field	Store Field	Notes
Sensitivities	VegaSensitivities	

Curvature

The **SaSensitivities** store contains the Curvature shocked prices.

The following table lists the fields in the store that are used for the Crypto 2a risk-class. See the SaSensitivities store documentation for details on the store.

Data Model Field	Store Field	Notes
As-Of Date	AsOfDate	
Trade ID	TradeId	
Risk Factor Name	Risk Factor	
Risk Class	RiskClass	“Crypto 2a”
Risk Measure	Risk Measure	“Curvature”
Shock Up	Shift_Up_PV	Vector-valued. Same size as Risk Weight
Shock Down	Shift_Down_PV	Vector-valued. Same size as Risk Weight
Risk Weight	RiskWeight	(optional) Vector-valued
PV Applied	PVApplied	‘Y’ or ‘N’
Sensitivity Currency	Ccy	

Cube Schema (Reference Implementation)

The following table lists the levels and hierarchies in the Cube schema that are used in the Crypto 2a data model.

Data Model Field	Cube Level	Notes
As-Of Date	AsOfDate	Slicing Hierarchy
Trade ID	TradeId	

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Data Model Field	Cube Level	Notes
Risk Class	Risk Class	“Crypto 2a”
Risk Measure	Risk Measure	“Delta”, “Vega”, “Curvature”
Bucket	Crypto 2a Bucket	Crypto asset
Risk Factor Name	Risk Factor	
Sensitivity Tenor / Option Maturity	Vertex	Analysis Hierarchy
Underlying	Underlying	Crypto asset and exchange for delta/curveture, crpyo asset for vega
Location	Crypto 2a Exchange	
	Crypto 2a Delta Double Sums	Levels for the Delta Double Sums and Correlations
	Crypto 2a Vega Double Sums	Levels for the Vega Double Sums and Correlations

Configuration (Core)

This section describes how the required constants (e.g. risk weights) are set for calculation of the Crypto 2a risk charge.

Vertices

The list of Crypto 2a Delta Tenors and Vega Option Maturities.

The file **Vertices*.csv** is loaded into the **Vertices** store.

Data Model Field	File Column	Datastore Column	Notes
	Index	Index	0-11 (Delta) 0-4 (Vega)

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Data Model Field	File Column	Datastore Column	Notes
Sensitivity Tenor / Option Maturity	Vertex	Vertex	Delta Tenors in [SCO60.74](2) Vega Option Maturities in [SCO60.75]
Risk Class	Risk Class	RiskClass	“Crypto 2a”
Risk Measure	Risk Measure	Risk Measure	“Delta” or “Vega”

Crypto 2a Parameters

The file **FRTBParameters*.csv** is loaded into the **FRTBParameters** store.

Parameter	Parameter Name	Default Value
Delta risk weight in [SCO60.73]	sa.crypto.group-2a.delta.risk-weight	1
Vega risk weight in [SCO60.73]	sa.crypto.group-2a.vega.risk-weight	1
Delta ρ_{kl} in [SCO60.76]	sa.crypto.group-2a.delta.rho-correlation	0.94
Vega ρ_{kl} in [SCO60.76]	sa.crypto.group-2a.vega.rho-correlation	0.94
Curvature risk weight in [SCO60.81]	sa.crypto.group-2a.vega.risk-weight	1

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