1. SENSITIVITY

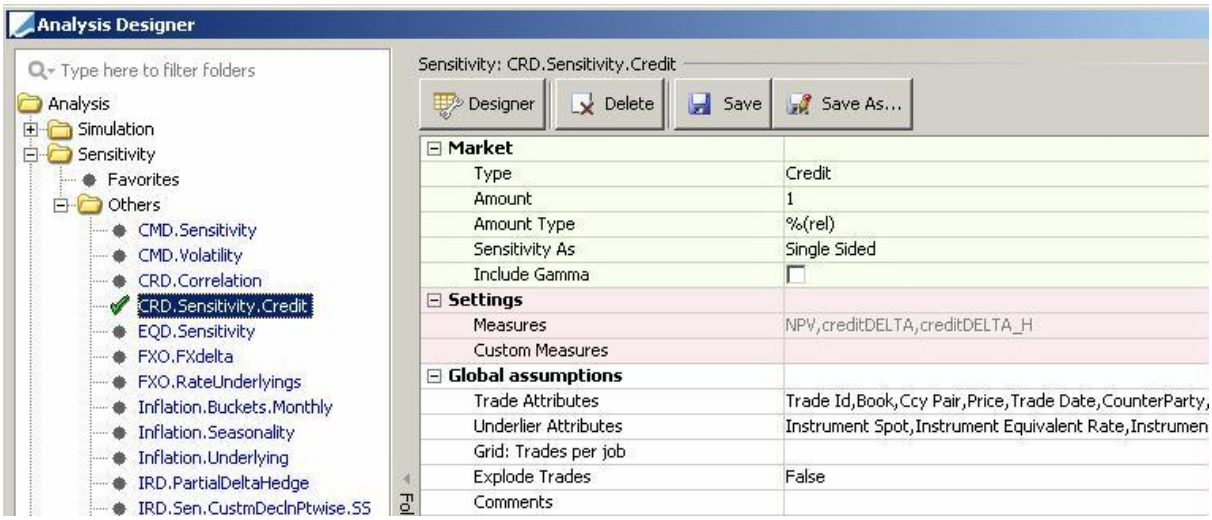
Revision Date	Comment
April 2011	First edition for version 12.0.

The Sensitivity analysis allows showing the discrete sensitivity of a portfolio's value to changes in the value of the underlying instruments of the market data used to price the portfolio.

The Sensitivity analysis also provides a Hedge analysis. It can analyze a portfolio and a set of user-defined hedging instruments, and produces a recommended set of hedging trades. In the Calypso Workstation, you can view the rate sensitivity and the hedge recommendations. If you want to add/remove hedging instruments on-the-fly, and create the hedging trades, you need to run the Hedge analysis in the Trade Blotter.

It can be configured from Main Entry > Configuration > Reporting & Risk > Analysis Designer. Right-click the Sensitivity folder in Analysis Designer, and choose "New Analysis" to add a parameter configuration, you will be prompted to enter a configuration name.

You can also use the parameter configurations provided out-of-the-box.



» Complete the parameter details.

» Click **Save** to save the configuration.

Contents

1.1 DEFINING SENSITIVTY PARAMETERS

Select the type of sensitivity you want to analyze from the Type field - It dictates the other selections.

- Equity - To shift the reference equity index of the Beta value.
- Commodity - To shift the underlying instruments of a commodity forward curve.
- Inflation - To shift the underlying instruments or seasonality of an inflation curve.
- Credit - To shift the underlying instruments of a credit curve.
- Rate - To shift the underlying instruments of an interest rate curve.
- FX Spot - To shift the spot rate of a currency pair.
- Volatility - To shift the volatility points, or the underlying instruments of a volatility surface.
- Correlation - To shift the correlation points of a correlation surface.

Global assumptions allow selecting trade attributes, attributes of the shifted items, the number of trades per job for grid computing, and whether to explode trades or not.

[**NOTE**: The following settings are limited to prevent running into memory and performance issues:

- No more than 20 trade attributes
- No more than 20 underlier attributes
- Cannot select more than 10 pricer measures
- Cannot compute more than 500 pricer measures per trade overall (number pf pricer measures * number of shifts / axis * number of axes)]

1.1.1 Equity Sensitivity

EQD.Sensitivity

Designer | Save | Save As...

Market	
Type	Equity
Beta: Reference Index	EquityIndex.SPX
Settings	
Measures	equityDELTA,equityBetaDELTA,equityB...
Custom Measures	equityUnitDELTA,equityUnitGAMMA
Global assumptions	
Trade Attributes	Trade Id,Book,Underlying Security,Tra...
Underlier Attributes	Underlier Beta,Underlier Country,Under...
Grid: Trades per job	0
Explode Trades	False
Comments	

» Select the reference equity index of the Beta value - Beta values are created using Main Entry > Market Data > Correlation & Covariance > Beta Value - Help is available from that window.

» Select the risk measures you want to compute.

- **equityBetaDELTA** = Beta adjusted amount of the underlying in Local currency. This amount is numerically calculated, using a 1% Beta shift upwards in the underlying spot.
- **equityBetaGAMMA** = Change in equityBetaDELTA for a 1% Beta Adjusted move in the underlying. It is numerically calculated as:

  equityBetaGAMMA = (NPV(1%BetaUp)+ +NPV(1%BetaDown)-2*NPV_BASE) / 1%

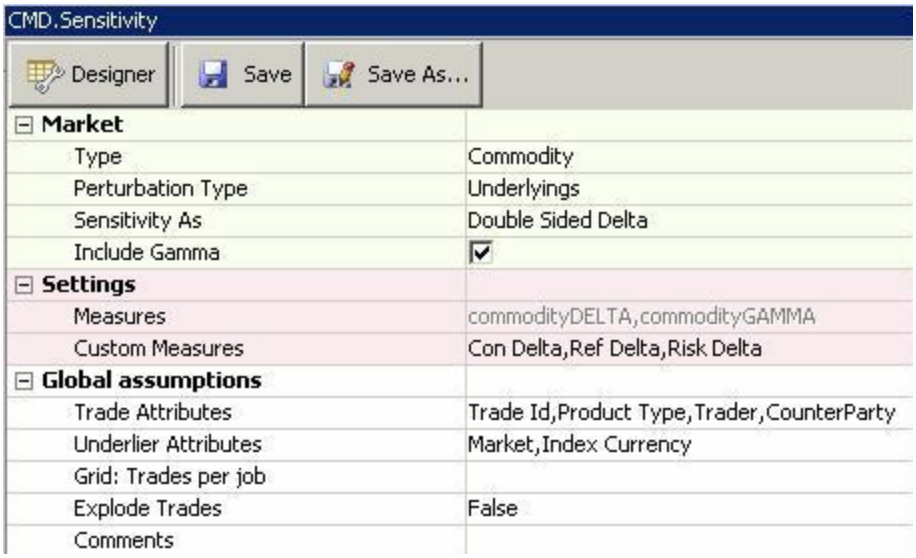
  BetaUp = 1%*Beta, BetaDown= -1%*Beta
- **equityDELTA** = Change in NPV for 1 % relative shift up in the underlying quote. The resulting difference in NPV is divided by the shift amount. For example an NPV difference of 200 USD is divided by the shift amount of 0.01 and the resulting equityDelta will be 20 000.
- **equityGAMMA** = Change in equityDELTA for 1 basis point shift up in the reference equity index value.

- **equityVEGA** = The exposure to a one percent (relative) parallel move in the underlying's volatility surface. This is numerically calculated.

You can also select custom measures if any custom measure is defined. You cannot currently define custom measures, you can only use the pre-defined ones.

- **equityUnitDELTA** = The exposure to the underlying expressed in units. It is calculated as equityDELTA / Spot(Prevailing).
- **euityUnitGAMMA** = The Gamma expressed in units of the underlying. It is calculated as equityGAMMA / Spot(Prevailing).

1.1.2 COMMODITY SENSITIVITY



» Select the perturbation type: Underlyings or Points.

» Select Single Sided (shift up), or Double-Sided Delta (shift up and down). You can also select Gamma.

» The risk measures are selected automatically:

- **commodityDELTA** = Change in NPV for 1% shift in the underlying instruments of the forward commodity curve
- **commodityGAMMA** = Change in commodityDELTA for 1% in the underlying instruments of the forward commodity curve

You can also select custom measures if any custom measure is defined. You cannot currently define custom measures, you can only use the pre-defined ones.

- **Ref Delta** = Delta in terms of the commodity's reference unit. The Reference Unit is the unit specified in the "Quote Unit" field in the Commodity definition. Ref Delta = CommodityDELTA/Tic. The CommodityDelta is normalized by dividing by the shift amount so that the size of the shift does not impact the results.
- **Risk Delta** = Delta in terms of the commodity's secondary risk unit. This is the unit specified in the "Risk Unit" field in the Commodity definition. This can be the same or different than the Ref Unit. Risk Delta = Ref Delta * Conversion, where Conversion is the unit conversion from the commodity conversion table from ref units to risk units.
- **Con Delta** = Delta in terms of the commodity's proxy future contract equivalents. Con Delta = Ref Delta * Conversion, where Conversion is the unit conversion from the commodity conversion table from ref units to Contracts.

- **Weighted Ref Delta** = The Reference Delta for a given underlying adjusted to prompt contract equivalents. Weighted Ref Delta = Ref Delta * Beta. The weights are entered in the Commodity Weight Window.

  The weights are applied to the underlying instruments of the curves. The last weight value applies to the remaining underlying instruments, if any.

  See Capturing Commodity Risk Weights for details.

1.1.3 Inflation Sensitivity

» Select the perturbation type:

- Seasonality - To shift the seasonality adjustments
- Underlyings - To shift the underlying instruments of the inflation curve
- Buckets - To shift the underlying instruments of the inflation curve by buckets. You can select the size of the buckets: Monthly, Quarterly, or Annually.

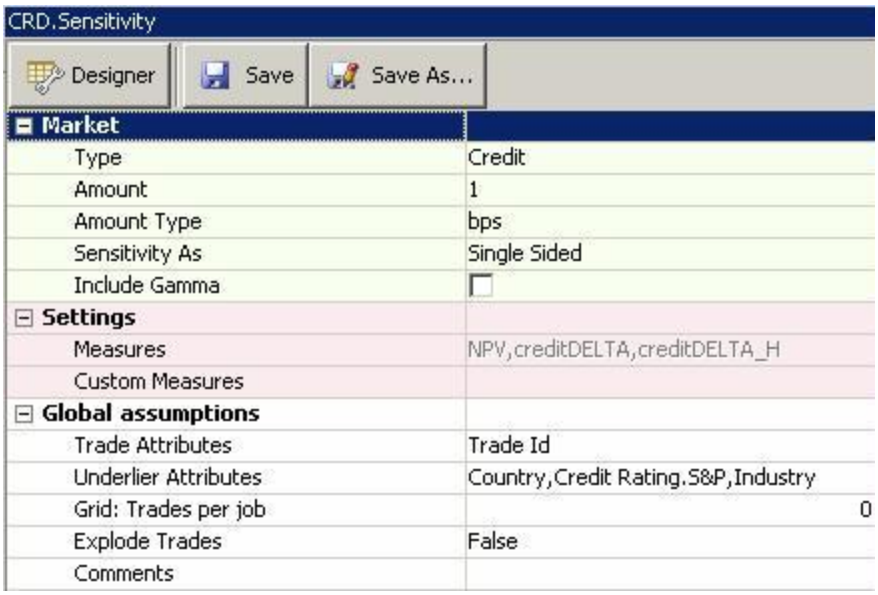
» Enter the shift amount, and select the amount type: absolute basis points, or relative percentage. Example: If you specify a relative percentage of 10%, a value of 120 will move to 132.

» Select Single Sided (shift up), or Double-Sided Delta (shift up and down). You can also select Gamma.

» The risk measures are selected automatically:

- **NPV**
- **inflationDELTA** = Change in NPV for a user-defined shift amount applied to the underlying instruments of the inflation curve

1.1.4 CREDIT SENSITIVITY



» Enter the shift amount, and select the amount type: absolute basis points, or relative percentage. Example: If you specify a relative percentage of 10%, a value of 20bps will move to 22bps.

» Select Single Sided (shift up), or Double-Sided Delta (shift up and down). You can also select Gamma.

» The risk measures are selected automatically:

- **NPV**
- **creditDELTA** = Change in NPV for a user-defined shift amount applied to the underlying instruments of the credit curve

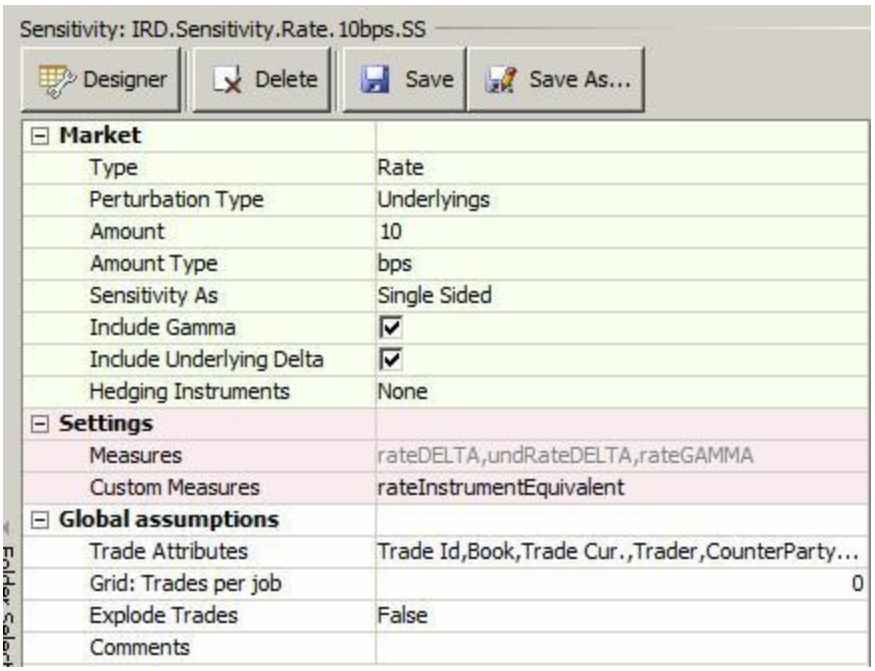
  Single sided = +1bp shift will move the credit curves 1bp up. creditDELTA = NPV shifted up – NPV base

  Double Sided = +1bp shift will move the credit curves 1bp up and 1bp down. creditDELTA = (NPV shifted up – NPV shifted down)/2
- **creditDELTA_H** = Change in creditDelta for a hedge instrument with a Notional of 1, 000,000 (a trade corresponding to the curve underlying instrument)

You can also select custom measures if any custom measure is defined. You cannot currently define custom measures, you can only use the pre-defined ones.

- **creditInstrumentNotional** = 1,000,000/creditDELTA_H. It gives the trade nominal that allows to achieve a delta neutral position on this underlying instrument.

1.1.5 RATE SENSITIVITY



» Select the perturbation type:

- Underlyings - To shift the underlying instruments of the interest rate curve
- Buckets - To shift the underlying instruments of the interest rate curve by tenor buckets - You need to specify the buckets in the Measure Maker window - Click **Designer** to open the Measure Maker window.

  See Analysis Designer - Measure Maker for details.
- Buckets (pointwise) - To shift the underlying instruments of the interest rate curve by point buckets - You need to specify the buckets in the Measure Maker window - Click **Designer** to open the Measure Maker window.

  See Analysis Designer - Measure Maker for details.

» Enter the shift amount, and select the amount type: absolute basis points, absolute percentage, or relative percentage. Example: if you specify a shift of 10%, a value of 40% will move to 50% with an absolute percentage, and 44% with a relative percentage.

For "Buckets" and "Buckets (pointwise)" perturbations, select the bucket configuration defined in the Measure Maker window.

» Select Single Sided (shift up), or Double-Sided Delta (shift up and down). You can also select Gamma.

» Hedging Instruments - You can select a set of hedging instruments to compute the Hedge analysis, or None otherwise.

See Hedge Analysis below for details.

» The risk measures are selected automatically:

- **rateDELTA** = The result depends on the perturbation type:

  Perturbation type =Underlyings: Change in NPV for a user-defined shift amount applied to the underlying instruments of the rate curve

  Perturbation type =Buckets: Change in NPV for a user-defined shift amount applied to the zero rates of the rate curve. The applied shift is a "Square shift". We shift all points included in a particular bucket. For example, to shift a 3M bucket, we will shift all points between 0D and 3M.

Perturbation type =Buckets (pointwise): Change in NPV for a user-defined shift amount applied to the zero rates of the rate curve. The applied shift is a "Triangle shift". We shift a particular point of the curve that corresponds to the Bucket (for example point 2) and we also shift gradually the points around point 2. So the effect of shifting point 2 is spread out gradually between points 1 and 3 with a peak at point 2.

- **undRateDELTA** = Change in NPV of a trade corresponding to the curve underlying instrument ("hedge trade"). Hedge trade nominal = 1,000,000. We apply the selected shift amount on the credit curve and price the hedge trade to get its DELTA. This number is then used to calculate rateInstrumentEquivalent
- **rateGAMMA** = Change in rateDELTA for user-defined shift amount in the underlying instruments of the interest rate curve

You can also select custom measures if any custom measure is defined. You cannot currently define custom measures, you can only use the pre-defined ones.

- **rateInstrumentEquivalent** = rateDELTA * 1,000,000/ undRateDELTA. It gives the trade nominal needed to achieve a delta neutral position on this underlying instrument

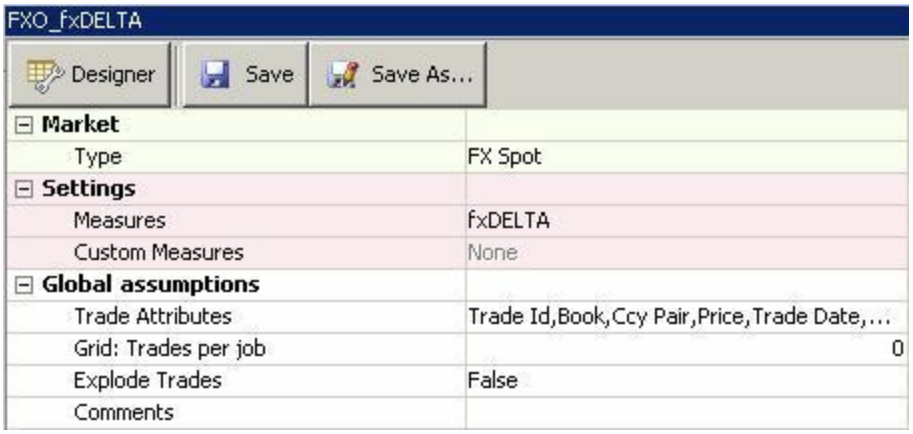
Hedge Analysis

The Rate Sensitivity can analyze a portfolio and a set of user-defined hedging instruments, and produces a recommended set of hedging trades. In the Calypso Workstation, you can view the rate sensitivity and the hedge recommendations. If you want to add/remove hedging instruments on-the-fly, and create the hedging trades, you need to run the Hedge analysis in the Trade Blotter.

You need to specify the hedging instruments in the Measure Maker window - Click **Designer** to open the Measure Maker window.

See Analysis Designer - Measure Maker for details.

1.1.6 FX Spot Sensitivity



» The risk measure is selected automatically:

- **fxDELTA** = Numerically shifts the FX Spot rate up and down by one pip to recalculate the NPV difference then averages these two. The resulting difference in NPV is rescaled to display as the equivalent delta currency amount in currency units.

  For example; a USD1,000 average NPV difference from the 1 pip shifts for a EUR/USD position would be rescaled to be a EUR10,000,000 fxDELTA.

  This risk measure applies to all FX trades, and to non-FX trades that are saved with the trade keyword "CurrencyPair" set to a valid currency pair.

  The currency for the fxDELTA units is based on the setting of "Delta Display Currency" in the currency pair configuration.

1.1.7 VOLATILITY

» Select the volatility type: Credit, Rate, Equity, Commodity, or FX.

» Select the perturbation type: Points (to shift the volatility points), or Underlying Instruments (to shift the underlying instrument - not available for Rate).

For FX, you have the choices of underlyings instruments:

- Underlying Instruments (ATM, Vanilla Puts an Calls) - In this case, you can enter the absolute shift in percentage.
- Underlying Instruments (ATM, RR and FLY) - In this case, you can select the shift type,and you can enter the ATM absolute shift in percentage and the strategy absolute shift in percentage.

  The following shift types are available:

  "All Strategies Separately"

  "25D Equivalent"

  "ATM Only"

» Vega is computed by default. You can include Volga and Vanna.

Perturbation is sequential and parallel only.

Process: Shift the underlying instruments or volatility points individually per each Strike, each Expiry Date and per each Tenor. Re-price the trade/portfolio. The result is one shifted NPV for a combination of Tenor, Strike and Expiry Date. Sensitivity will be calculated as difference between shifted NPV and BASE NPV. There will be one sensitivity per combination of Tenor, Strike and Expiry Date.

- **Vega**

  N(S, v) = NPV at underlying spot/zero price/rate S and volatility v

  dS = shift in underlying price

  dv = shift in volatility

  Vega = Vega(S, v) = N(S, v + dv) - N(S, v)
- **Volga** (change in Vega with respect to change in Volatility)

  Volga = Volga(S, v) = N(S, v + dv) - 2 * N(S, v) + N(S, v - dv)
- **Vanna for Rate and Commodity** = Change in Delta with respect to change in Volatility

  Vanna on Rate Volatility: dS = Rate Shift => IR curve (same currency and rate index than the volatility surface ones) will be shifted simultaneously. Shift amount is set to 1bp absolute.

Vanna on Commodity Volatility: dS = Commodity Spot Quote Shift => will be applied on the Commodity Forward curve corresponding to the Product defined on the Commodity Vol Surface. The curve will be shifted simultaneously and shift amount is set to 1% relative.

- **Vanna for FX Volatility** = Change in Vega with respect to change in Volatility

  Vanna on FX Volatility: dS = FX Spot Quote Shift => will be applied to the FX rate quote corresponding to the currency pair defined on the Volatility surface. Shift amount is set to 1 pip absolute.

  Vanna on Equity Volatility: dS = Equity Spot Quote Shift => will be applied to the Equity product spot quote Shift amount is set to 1 % relative.

- Vanna is not available for Credit.

"25D Equivalent" Methodology

This perturbation is applied on underlying instruments and to a surface derived from Strategies.

The 25-delta strategy will be the reference.

In this case 0.1% additive will be applied as it is to the 25 - delta strategies.

1% additive will be applied to the ATM instrument.

The shift amount applied on "like" strategies for the same expiry but for a different delta will be adjusted by a ratio.

All instruments corresponding to the same strategy type (RR or STR or BF) and the same Expiry will be shifted simultaneously together.

The output will be one Vega, Volga, Vanna per instrument type (RR, STR, BF, ATM) and per Expiry.

Ratio = This is the ratio of the strategy volatility that is NOT the 25 delta to the 25 Delta volatility. Note: this is found from the surface itself. It is not entered by the user in the Sensitivity configuration.

Shift amount (0.1%) applied on strategies with a delta that is not 25-delta = 0.1% * Ratio

For example the 25 delta RR for 2 month has a spot value of 1.0 and the 10 delta value is 1.7 so the ratio is 1.7. The 25 delta underlyings will be moved by 0.1% to 1.1 and the 10 deltas will be moved by 0.17 to 1.87.

Impact on Underlier Attributes:

- Instrument Strike = 25 RR, 25 BF, 25 STR, ATM
- Instrument Name = reference instrument name (for example "EUR/USD 2D Risk Reversal 25-delta", "EUR/USD 3M Strangle 25-delta", "EUR/USD 2D Butterfly 25-delta", "EUR/USD 1W ATM")

1.1.8 CORRELATION

» Select the correlation type: Rate/FX, Rate, Equity, Equity/FX, or Basket.

» Perturbation is sequential and parallel only.

NPV_Diff (NPV shifted – BASE NPV). It is numerically calculated by shifting the correlation points sequentially by 1% up, and recalculating the NPV of the trade/portfolio.

- **Rate** = Shift the correlation points individually per each combination of Index/Index and Tenor.
- **Rate/FX** = Shift the correlation points individually per each combination of Index/FX and Tenor.

  The result is one shifted NPV per combination of Index/Index and Tenor (or Index/FX and Tenor). Sensitivity will be calculated as difference between shifted NPV and BASE NPV. There will be one sensitivity per combination of Index/Index and Tenor (or each Index/FX and Tenor).
- **Equity** = Shift the correlation points individually per each combination of Equity/Equity or Equity/EquityIndex or EquityIndex/EquityIndex and Tenor.
- **Equity/FX** = Shift the correlation points individually per each combination of Equity/FX and Tenor

  The result is one shifted NPV per combination of Equity/Equity and Tenor (or Equity/FX and Tenor). Sensitivity will be calculated as difference between shifted NPV and BASE NPV. There will be one sensitivity per combination of Equity/Equity and Tenor (or each Equity/FX and Tenor).
- **Basket**

  Liquid Correlation surface: correlation points are shifted.

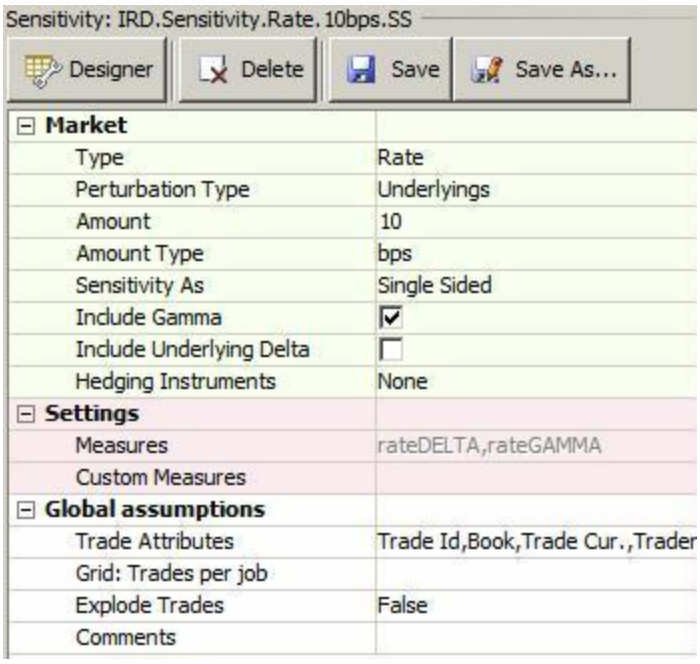
  Bespoke Correlation surface: Liquid Correlation surface points are shifted. If Correlation Formula is used, the correlation points of all Liquid Correlations are shifted (separately), the Bespoke Correlation is re-generated and the trade/portfolio is priced to get shifted NPV.

  Each of the liquid correlation surfaces are shifted separately means that we shift first liquid correlation and calculate the sensitivity to this surface. Then we shift the second liquid correlation surface etc.

  Perturbation will be sequential and parallel only. Shift the points individually per each Tranche and per each Tenor. The result is one shifted NPV per Tenor per Tranche.

1.2 Sample IRD Sensitivity

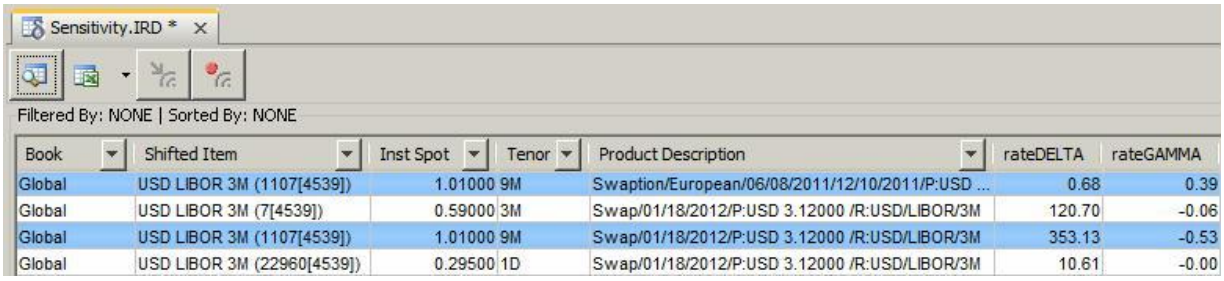
1.2.1 IRD Sensitivity Parameters



1.2.2 IRD Sensitivity Results in Calypso Workstation

Click **Workstation** in Main Entry to bring up the Calypso Workstation.

Refer to Calypso Workstation documentation for complete setup details.

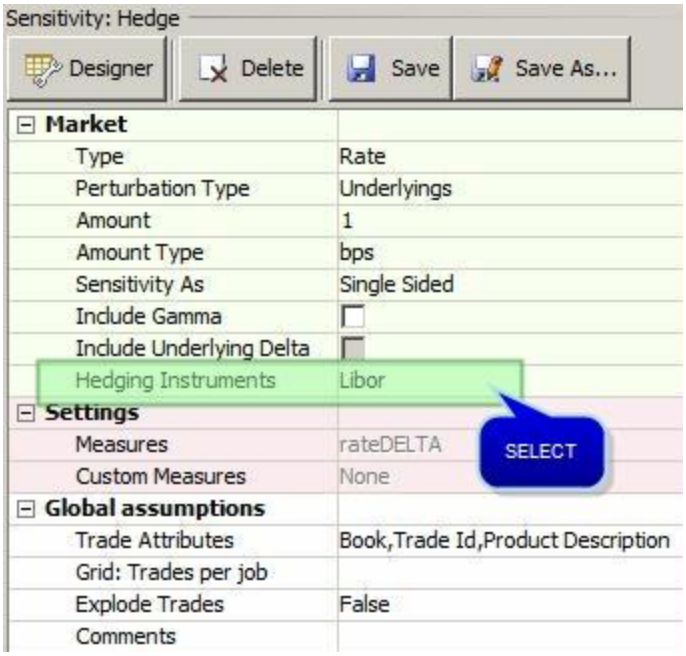


Book	Shifted Item	Inst Spot	Tenor	Product Description	rateDELTA	rateGAMMA
Global	USD LIBOR 3M (1107[4539])	1.01000	9M	Swaption/European/06/08/2011/12/10/2011/P:USD ...	0.68	0.39
Global	USD LIBOR 3M (7[4539])	0.59000	3M	Swap/01/18/2012/P:USD 3.12000 /R:USD/LIBOR/3M	120.70	-0.06
Global	USD LIBOR 3M (1107[4539])	1.01000	9M	Swap/01/18/2012/P:USD 3.12000 /R:USD/LIBOR/3M	353.13	-0.53
Global	USD LIBOR 3M (22960[4539])	0.29500	1D	Swap/01/18/2012/P:USD 3.12000 /R:USD/LIBOR/3M	10.61	-0.00

You can configure the display using Settings > Configure View.

1.3 Sample Hedge Analysis

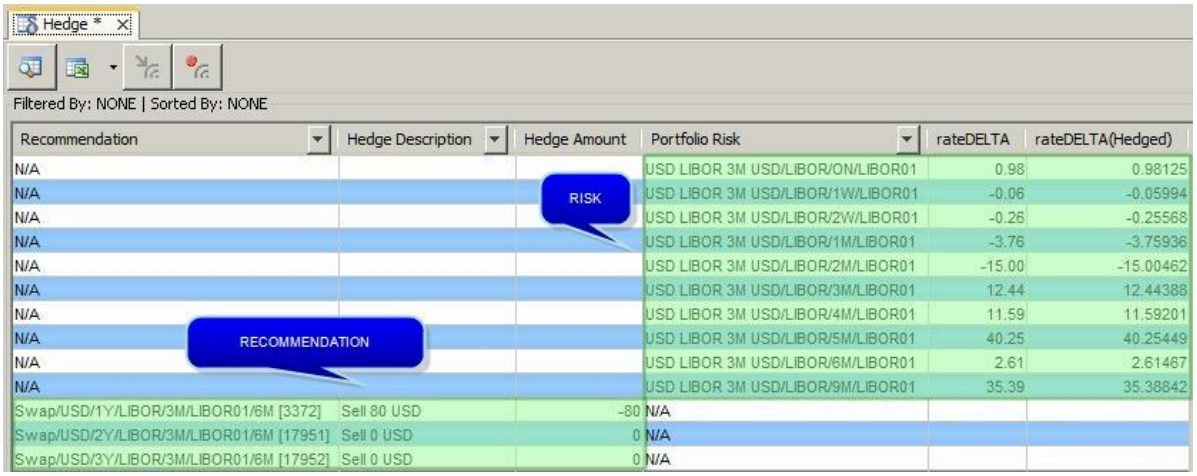
1.3.1 Hedge Parameters



» Select a set of hedging instruments.

1.3.2 Hedge Results in Calypso Workstation

Click **Workstation** in Main Entry to bring up the Calypso Workstation.
Refer to Calypso Workstation documentation for complete setup details.



The Hedge Recommendation is represented by the rows with a recommendation, a hedge description, and a hedge amount.

The other rows represent the Rate Sensitivity.

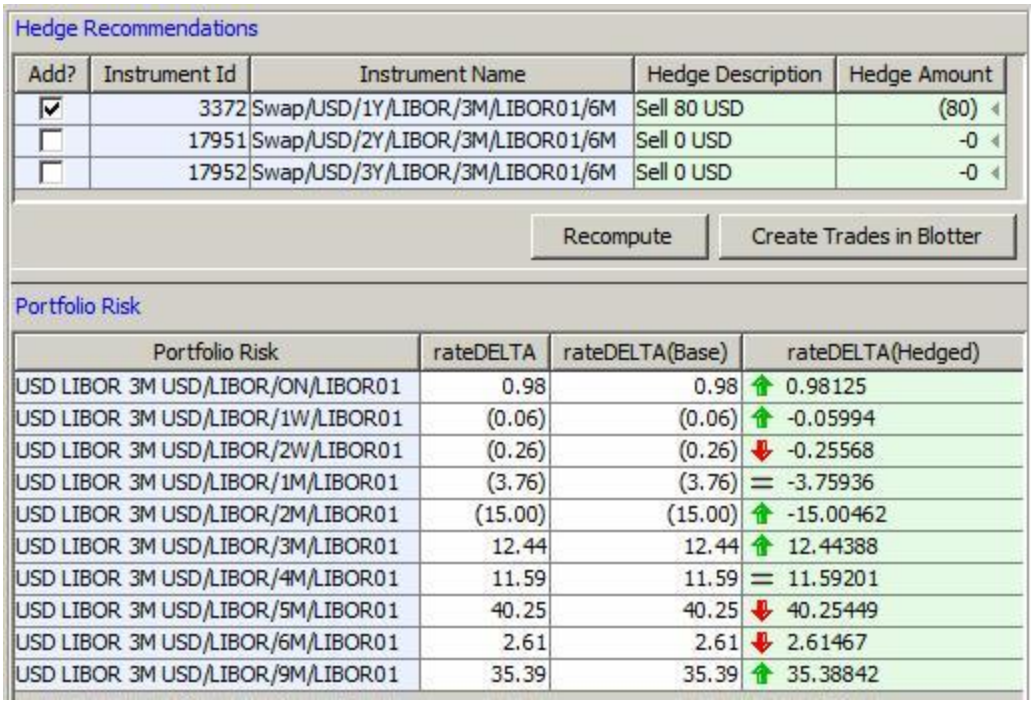
You can configure the display using Settings > Configure View.

1.3.3 Hedge Results in Trade Blotter

Choose Main Entry > Deal management > Trade Blotter to bring up the Trade Blotter.

Select a set of trades from a blotter, and run the Hedge analysis from the Risk window.

Refer to Calypso Trade Blotter documentation for complete setup details.



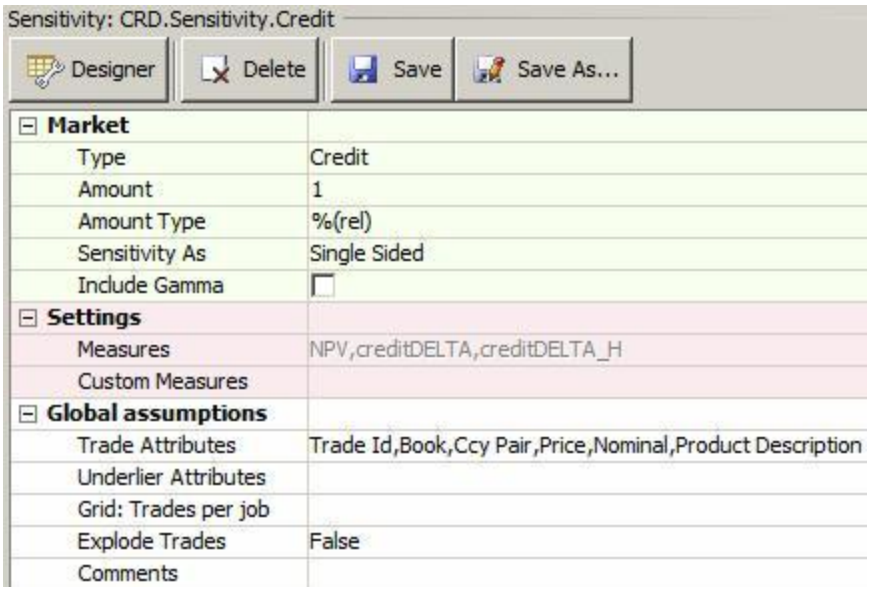
The upper panel shows the recommendations for the selected trades, and the lower panel shows the risk.

You can add / remove hedging instruments by checking / unchecking the "Add?" checkboxes. Then click **Recompute** to obtain the new hedge recommendations.

You can click **Create Trades in Blotter** to create the hedge trades. You will be prompted to select a workspace. The trades will be added to the workspace but not actually saved. You can save the trades as applicable.

1.4 Sample Credit Sensitivity

1.4.1 Credit Sensitivity Parameters

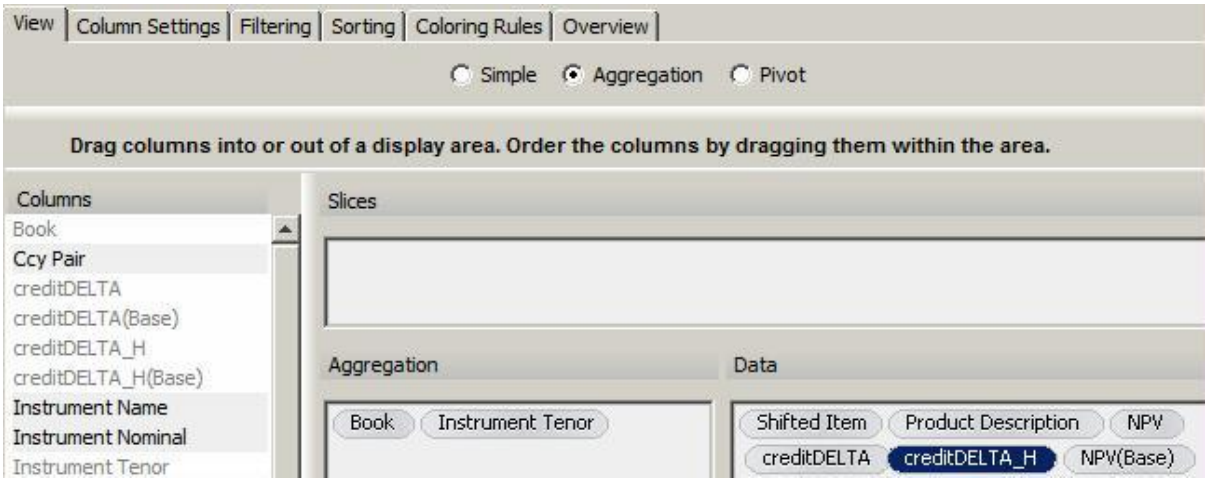


1.4.2 Credit Sensitivity Results in Calypso Workstation

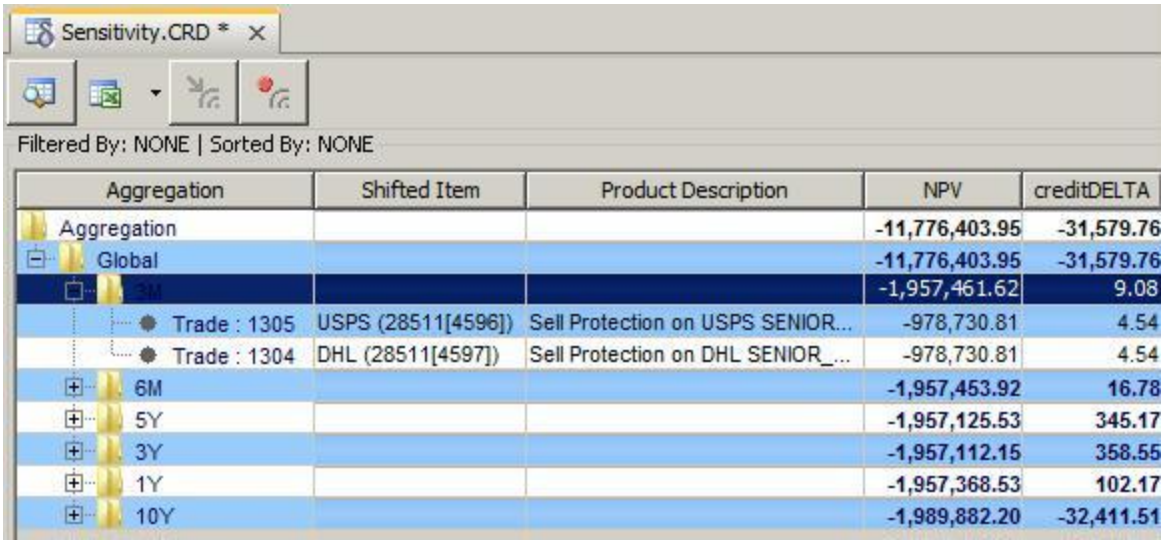
Click **Workstation** in Main Entry to bring up the Calypso Workstation.

Refer to Calypso Workstation documentation for complete setup details.

Sample aggregation view configuration



Sample results



Aggregation	Shifted Item	Product Description	NPV	creditDELTA
Aggregation			-11,776,403.95	-31,579.76
Global			-11,776,403.95	-31,579.76
3M			-1,957,461.62	9.08
Trade : 1305	USPS (28511[4596])	Sell Protection on USPS SENIOR...	-978,730.81	4.54
Trade : 1304	DHL (28511[4597])	Sell Protection on DHL SENIOR_...	-978,730.81	4.54
6M			-1,957,453.92	16.78
5Y			-1,957,125.53	345.17
3Y			-1,957,112.15	358.55
1Y			-1,957,368.53	102.17
10Y			-1,989,882.20	-32,411.51

You can configure the display using Settings > Configure View.

2. Analysis Designer - Measure Maker

For Simulation, this window allows defining non-parallel shifts: shifts of different amounts for different maturity buckets.

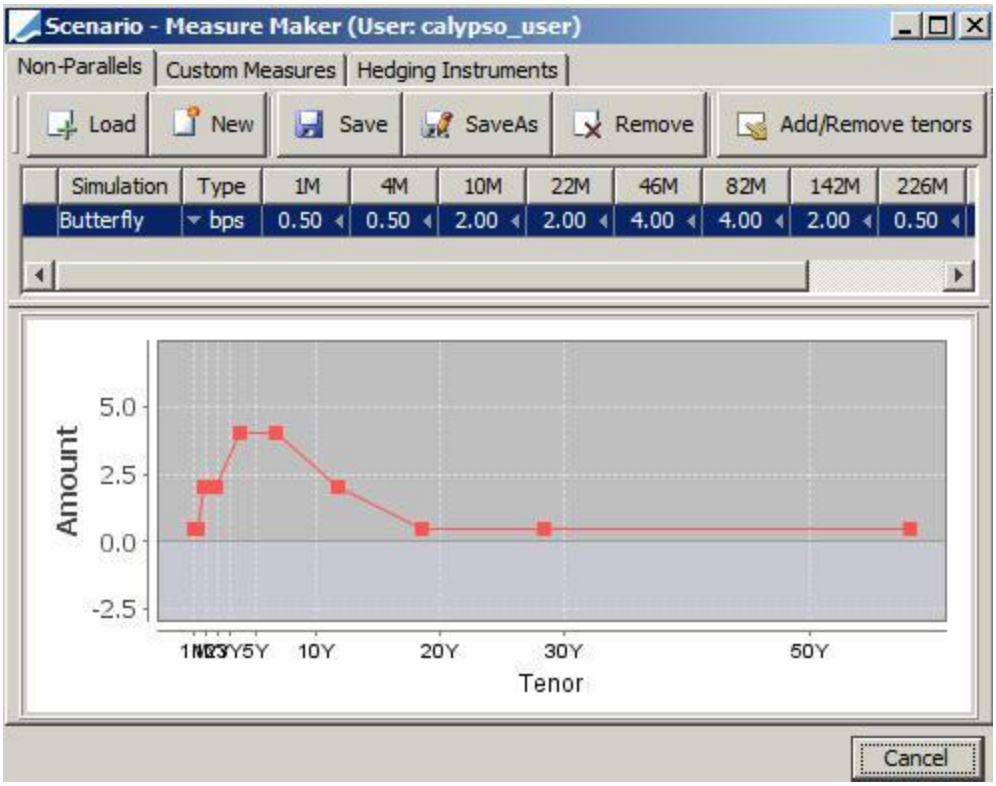
For Sensitivity, this window allows defining buckets and hedging instruments.

2.1 Defining Non-Parallel Shifts

Select the Non-Parallels panel.

You can define non-parallel shifts for the simulation types Rate, Commodity, and Dividend.

You can define buckets for the Rate sensitivity.



Click **New** to create a set of shifts. You will be prompted to enter a name and to select tenors.

You can also click **Load** to load an existing set, and click **Add/Remove tenors** to modify the configuration as needed.

You can then enter the shift amount for teach tenor by entering a value for the tenor, or moving the point on the graph.

2.2 Defining Custom Measures

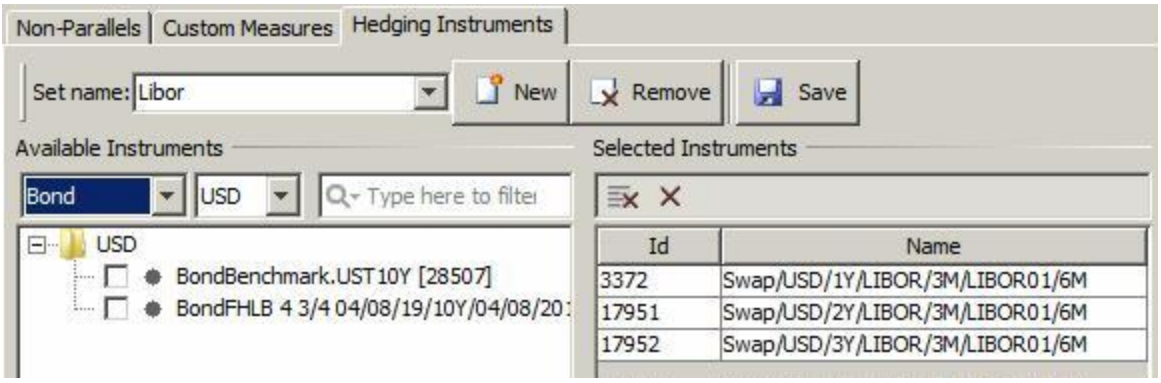
Not currently possible. You can only use pre-defined custom measures.

It shows however how the pre-defined custom measures are computed.

2.3 Defining Hedging Instruments

This only applies the Rate Sensitivity to select hedging instruments to compute the Hedge analysis.

Select the Hedging Instruments panel.



Click **New** to create a new set of hedging instruments. You will be prompted to enter a name.
You can also select a set name to load an existing set.

To add hedging instruments, select a type and a currency. The available instruments will appear. Check the instruments you wish to add. Then click **Save** to save your changes.

3. CAPTURING COMMODITY RISK WEIGHTS

You can use the Commodity Weight Window (menu action `refdata.CommodityWeightWindow`) to capture weights to compute "Weighted Ref Delta" in the Sensitivity analysis.

The weights are applied to the underlying instruments of the curves. The last weight value applies to the remaining underlying instruments, if any.

You can define weights for each commodity product.

» Click **...** next to the Commodity field to select a commodity product.

» Enter a number of weights and click **Generate**. Then enter the weight factors in the table.

You can add and remove rows to the table as needed.

» Click **Save** to save your changes.