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| SwapAgent: Cross currency swap  Proof of Concept |

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# Summary

## Goal of the POC

The goal of this proof of concept is to show if Murex can evaluate different type of cross currency basis swap product. It covers as well the computation of interest rate risk and foreign exchange risk using “Local currency – USD” basis curve.

## Scope of the POC

The exercise is run on the current LCH Murex version i.e. v3.1.27.16. It will be done in the VM space (*EOD Main* Market Data Set) which means that the pricing will be in a multi-curve world, the interest rate risk is however based on the hypothesis that the dependencies between rate curves are broken i.e. No propagation effect and no cross sensitivities are considered.

All trades are collateralized in USD in first phases of SwapAgent project for cross currency basis swap products and this statement is valid for this POC.

The following table describes the different cross currency basis swap products:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Product** | **Coupon Flows** | **Quotation** | **FX Rate** | **Notional Flows** |
| **Resettable Cross Currency Basis Swap** | Floating Rate 3m Index (foreign ccy) vs 3m USD Libor | Spread, in basis points, over foreign currency index | Variable every 3 months. USD amount cash-settled. | Initial and Final Exchange of notional |
| **Cross Currency Basis Swap** | Floating Rate 3m Index (foreign ccy) vs 3m USD Libor | Spread, in basis points, over foreign currency index | Agreed at time of trading. Same rate used for both initial and final exchange | Initial and Final Exchange of notional |
| **Fixed-Fixed** | Fixed Rate (foreign) vs Fixed Rate (domestic) | Customisable | Agreed at time of trading. Same rate used for both initial and final exchange | Initial and Final Exchange of notional |
| **Fixed-Float** | Fixed Rate vs Floating Rate | Spread over floating rate | Agreed at time of trading. Same rate used for both initial and final exchange | Initial and Final Exchange of notional |

The following specific cases are sufficient coverage for this POC:

* GBP-EUR fixed-fixed cross currency basis swap
* EUR-USD cross currency basis swap
* EUR-USD resettable cross currency swap

Rate curve assignment will hence be:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Type** | **Currency** | | **Discounting curve** | | **Forward curve** | |
| Leg1 | Leg2 | Leg1 | Leg2 | Leg1 | Leg2 |
| **Fixed-Fixed** | EUR | GBP | EUR USD BASIS | GBP USD BASIS | - | - |
| **Resettable** | EUR | USD | EUR USD BASIS | USD FEDFUND | EUR EURIBOR 3M | USD LIBOR 3M |
| **Non-resettable** | EUR | USD | EUR USD BASIS | USD FEDFUND | EUR EURIBOR 3M | USD LIBOR 3M |

Note that basis curves are outright curves and are not configured as spread curves on another OIS curves, they calibrate a total ZC directly from its own instruments. Note as well that those curves are considered as a FX curves and a discounting curves in the same time.

It is worth also noting that linear zero coupon rate interpolation is used for both pricing and risks evaluation for simplicity reason, Murex natural cubic spline interpolation on the log of discount factors algorithm has previously been validated.

Murex pricer (e-tradepad) and the simulation are the main screens used for the validation.

This POC does not give any proof about the capability of Murex on IM calculation nor for non-USD collateralisation currency. This will be done in a separate POC.

Not as well that Interest rate gamma is not planned to be validated.

## Outcome of the POC

* Basis curve: Basis curves calibrate correctly with resettable cross currency basis swaps as pillars.
* Evaluation: NPV for all types of cross currency basis swap is correctly reconciled and forward FX rate is correctly estimated using the assigned FX curves.
* Zero IR deltas: The zero deltas are matching the theoretical calculation which is based on direct sensitivities (ignoring FX cross sensitivities). There is a very small mismatch described in section 6.2.2 that can be ignored.
* PAR IR deltas: The PAR IR deltas are retrieved based on the Zero IR delta and the Jacobean matrix. However, Jacobean matrix is wrongly computed when FX swaps are components of a rate curve (section 6.1.2).=> corrected in the patch 3.1.27.16.en.10 (see section 7)
* FX Delta for “Local currency-USD” cross currency basis swaps: The theoretical calculation is in line with what Murex is producing.
* FX Delta for “Local currency- Local currency” cross currency basis swaps: FX deltas are reconciled but are projected in different outputs. This needs to be taking into account when building the risk report (section 6.2.1).
* FX delta is consistent during the trade lifecycle and the FX fixing procedure is correctly called.

It is worth mentioning that Murex is not able to handle non-USD collateralisation (section 2.2).

# Basis curve

## Basis curves definition

New basis curves will be defined is order to represent the foreign funding curve for non-USD currencies. Those curves will be used as discounting curves in the cross currency swap and as FX curves in order to estimate forward FX rates.

The instruments used in those curves will be:

* Swap Points (FX swaps) for the short end (O/N up to 18 Months)
* Resettable cross currency Basis Swaps for the long term of the curve (2Y to 30Y).

EUR USD Basis curve and GBP USD Basis curve will be configured with regard to the POC’s scope, below schemas showing their dependencies to existing curves as per the rate curve assignments:

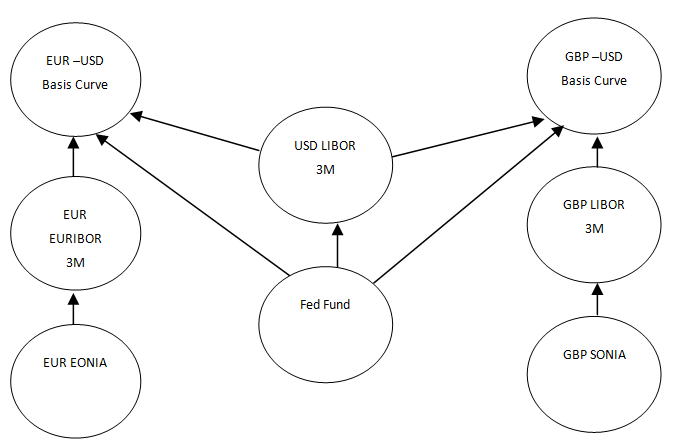


Figure : Basis curves dependencies

A B : Curve B calls the zero coupons of curve A when calibrating

## Synthetic curves

Non-USD currency is not planned to be used as a collateralisation currency in first phases of SwapAgent. However, the following paragraphs illustrate the notion of synthetic curves and shows Murex coverage on the subject.

### Collateralisation in non-USD currency:

USD is considered the “pivot” currency for the currency pairs of SwapAgent scope. “Local currency-USD” FX swaps and resettable cross currency swaps are the most liquid FX product in the market and considering “Local currency –USD” basis curves as “foreign” funding curves are legit.

“Local currency-USD” basis curve is the discounting curve for the local currency leg of a cross currency swap when USD is the collateralisation currency. However, and in order to respect the non-arbitrage logic, synthetic curves are needed as discounting curves when the collateralisation currency is in local currency.

It is important to note that the synthetic curves have the following characteristics:

* They have has no instruments; there are no calibration processes within the curves, only interpolation at specific dates.
* The synthetic curves do not bear or generate any risk on itself, but projects the risk onto three underlying curves (two FX curves and a funding curve).

Below examples of discounting curve assignment depending on the collateralisation currency:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Currency** | | Top of Form  **Collateralisation**  Bottom of Form | **Discounting curve** | |
| **Leg1** | **Leg2** | Top of Form  **currency**  Bottom of Form | **leg1** | **leg2** |
| **EUR** | **USD** | USD | EUR USD Basis | USD FedFund |
| **EUR** | **USD** | EUR | EUR EONIA | USD-EUR implied |

### The logic behind synthetic curves

The NPV of a USD flow taking into account the funding at EUR collateral rate can be written as:

The NPV of the same flow can be converted in EUR at payment date using the FX forward rate picked up by the two corresponding FX curves. The flow is then discounted at the funding rate which is the EUR EONIA and then converted back to USD using the FX spot rate:

With

By equalizing the above equations, the below formula is retrieved

### Murex “collateral based discounting” module

Murex has developed a collateral based discounting module (known as CSA module) that enables to assign the correct discounting curve depending on the collateralisation currency. The discounting curve can be the OIS curve if the discount is done in the local currency, the FX curve, or finally the synthetic curve.

This module enables to imply (on-the-fly) those synthetic curves based on a linear combination of existing curves and market data.

However, this module is available in higher version starting v3.1.30 (current version is v3.1.27).

### Is there a workaround solution in the current version?

The proposed workaround would consist of creating an inbound-outbound interface where the synthetic curve is calibrated outside Murex and fed back to Murex with “New dummy” calibrated quotes.

However, this proposal has several limitations and is heavy to implement. Listed below the drawbacks compared to the CSA module solution:

* The NPV is not accurate as the discounting factors of the synthetic curve won’t correctly be interpolated.
* IR risk (Par and Zero) is meaningless as the link to “real” curves is lost, while risk will be automatically projected to the real curve with CSA module.
* There is non-evaluated cost and risk to develop the solution outside Murex.
* Heavy additional configuration required.
* Additional workflows are required in order to mitigate operational risk.

For the above reasons, Risk team highly recommends the use of native Murex CSA module after the binary upgrade project for non-USD collateralisation.

# Analytical pricing and Risk formulas

Detailed formula used to reconcile Murex is described in this section

## Notations

Let’s denote the following (these notations will be used along the entire document):

* Flow date. This can be the start, end or forward evaluation date for a given period
* n: Number of the interest flows periods in the trade
* today’s date is noted
* i=0 corresponds to settlement date or spot date
* : The forward rate based on the forward curve used for a period i between and with i in
* Fixed rate of ccy leg
* : Basis spread added to the floating rate
* : Nominal expressed in currency to calculate the interest flow for the period i with i in
* The discount factor calculated from a curve between. It is following the exponential convention.
* : FX spot rate.
* FX discounted spot rate.
* : Accrual factor used in interest flows calculation
* : Accrual factor used in Libor and Euribor forward calculation
* Accrual factor used in discount factor calculation
* : Total of the interest rate delta coming from +1 basis point shift of the zero rates of the curve. The ‘*type’* is to differentiate between discounting, forward, FX forward or FX spot conversion risk
* : Zero IR delta vector projected on curve’s pillars dates
* : Total of the interest rate risk coming from +1 basis point shift of the market quoted of the curve.
* Par IR delta vector
* : The Jacobean matrix of the curve

## Common formulas:

### Forward rate:

The forward rate calculation is supposing that a linear convention is used:

### FX rate discounted:

### Forward FX rate:

### Par IR delta:

Par IR delta is based on zero IR delta projected on curve pillars multiplied by the Jacobean matrix of the curve

### FX spot conversion IR risk:

This is a very small risk that appears when converting the NPV of local currency leg to USD using the discounted FX rate. It is illustrated in the below example:

For a EUR-USD cross currency basis swap collateralised in USD, forward risk will appear due to the conversion of NPV of the EUR leg to USD using FX discounted rate

The risk is hence expressed on the two FX curves:

USD FedFund:

EUR USD Basis:

is still expressed in USD at this stage. It should still be converted to EUR using the discounted FX rate

Hence

## GBP-EUR Fixed-fixed cross currency swap:

### Cash flows

A basis cross currency swap has the following flows:

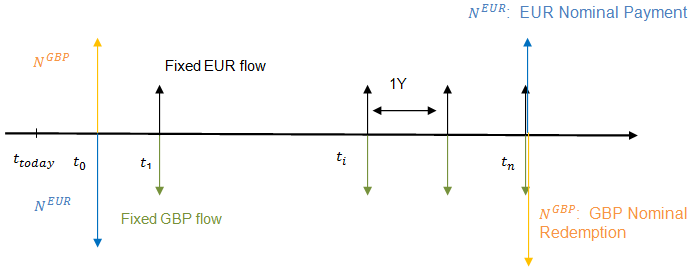


Figure : GBP-EUR Fixed-Fixed Xccy swap

### Net Present Value:

The NPV as priced in Murex pricer (e-tradepad) valued at **today’s Date** as the settlement delay follows the currency settlement delay. In this case, +0 open days for GBP. The NPV is calculated in GBP:

The notional is calculated using the FX spot agreed at trade inception

Today’s NPV expressed in GBP is converted to USD using the discounted FX spot.

### Zero IR delta:

* + - 1. EUR USD basis curve:
      2. GBP USD Basis curve:
      3. USD FedFund curve:

### FX delta:

As the collateralisation currency is different from the one used in the cross currency product. The FX delta is expressed against two FX spot (i.e. GBP-USD FX rate and EUR-USD FX rate)

The FX delta is then:

And

## EUR-USD cross currency basis swap:

### Cash flows

A basis cross currency swap has the following flows:

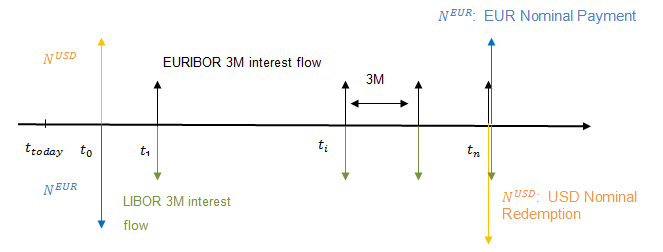


Figure : EUR-USD Xccy swap

### Net Present Value:

The NPV as priced in Murex pricer (e-tradepad) valued at **Spot Date** i.e. settlement date of the XCCS. In our case, +2 open days. The NPV is calculated in EUR:

The notional is calculated using the FX spot agreed at trade inception

Today’s NPV expressed in EUR is converted to USD using the discounted FX spot.

The formula is

### Zero IR delta:

* + - 1. EUR USD basis curve
      2. EUR EURIBOR 3M curve
      3. USD FedFund curve
      4. USD LIBOR 3M curve

### FX delta:

## EUR-USD resettable cross currency basis swap:

### Cash flows

EUR-USD resettable basis cross currency swap has the following flows:

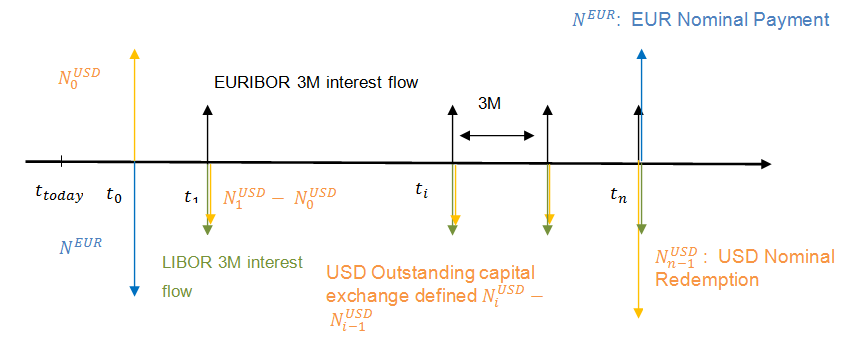


Figure : Resettable EUR-USD Xccy swap

### Net Present Value:

The NPV as priced in Murex pricer (e-tradepade) valued at **Spot Date** (ie settlement date of the XCCS. In this case, +2 open days. The NPV is calculated in EUR:

The notional is calculated using the FX forward calculation using EUR – USD Basis curve and USD FedFund curve (for i>0). It is calculated from Forward cash flow date to spot date:

Today’s NPV expressed in EUR is converted to USD using the discounted FX spot.

### Zero IR delta:

* + - 1. EUR USD Basis curve:

With

* + - 1. EUR EURIBOR 3M:
      2. USD Fedfund:
      3. USD LIBOR 3M:

### FX delta:

We start calculating the NPV XCCS in USD as of Spot date and we look for the FX delta against USD

**Already Fixed**

The FX delta is then (i starts from 2 to take into account that initial flows are already fixed):

# MX reconciliation:

Pricing and risks for the different cross currency basis swap is proven in the following paragraphs.

## GBP-EUR Fixed-Fixed cross currency basis swap:

### Trade definition

The trade is priced considering its first cash flow (Nominal Exchange) starts at spot date.

The fixed rate on the EUR leg is 1.5% and the one on the GBP LEG is 1%.

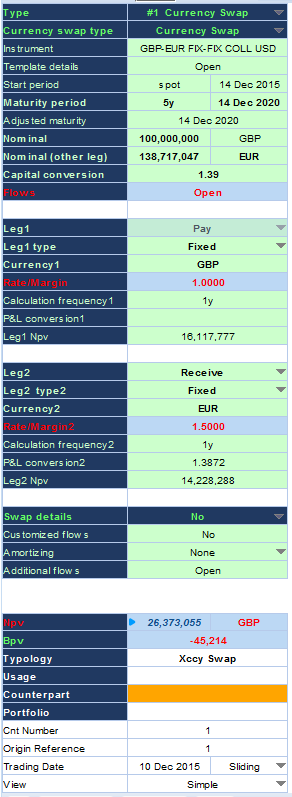


Figure : GBP-EUR Fixed Fixed Xccy trade definition

The system Date is **10/12/2015** and the start date for the FX rate is **14/12/2015**.

### NPV:

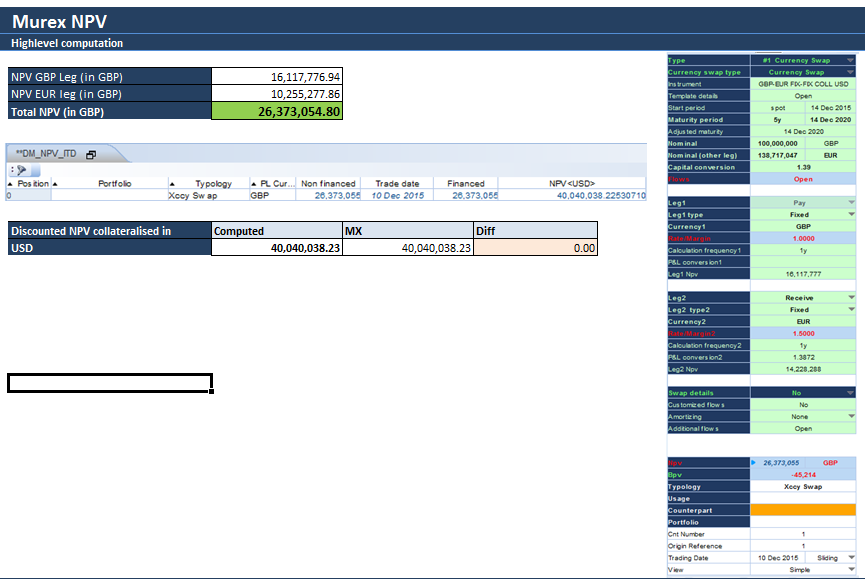


Figure : GBP-EUR Fixed Fixed Xccy NPV matching results

### IR delta discount GBP leg:

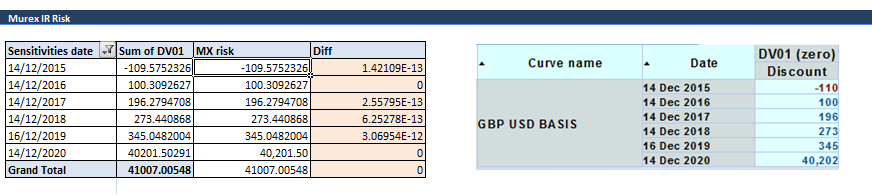


Figure :GBP-EUR Fixed Fixed Xccy IR delta discount GBP leg matching results

### IR delta discount EUR leg:

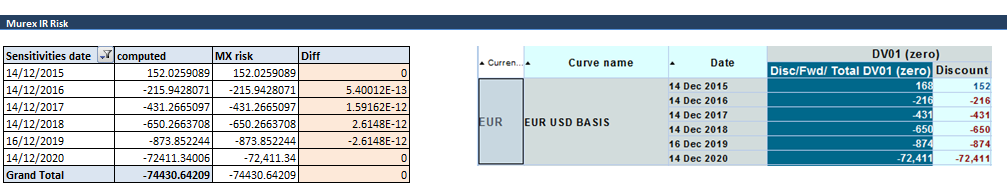


Figure : GBP-EUR Fixed Fixed Xccy IR delta discount EUR leg matching results

### FX spot conversion IR risk-GBP leg:

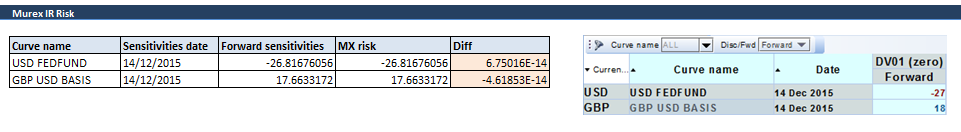


Figure : GBP-EUR Fixed Fixed Xccy FX spot conversion IR risk-GBP leg matching results

### FX spot conversion IR risk-EUR leg:

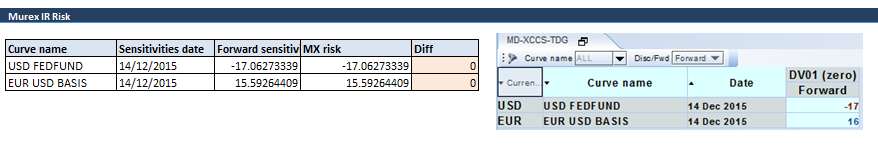


Figure : GBP-EUR Fixed Fixed Xccy FX spot conversion IR risk-EUR leg matching results

### FX delta:

More details about those results described in section 6.2.2

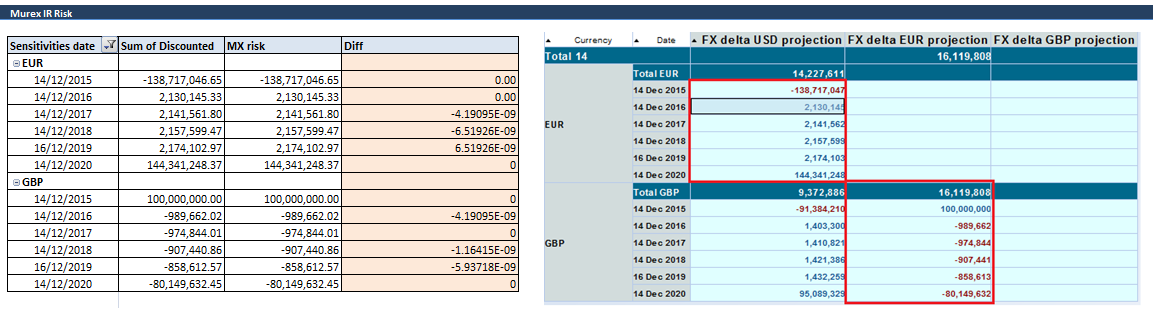


Figure : GBP-EUR Fixed Fixed Xccy FX delta matching results;

## EUR-USD cross currency basis swap:

### Trade definition

The trade is priced considering its first cash flow (Nominal Exchange) starts at spot date.

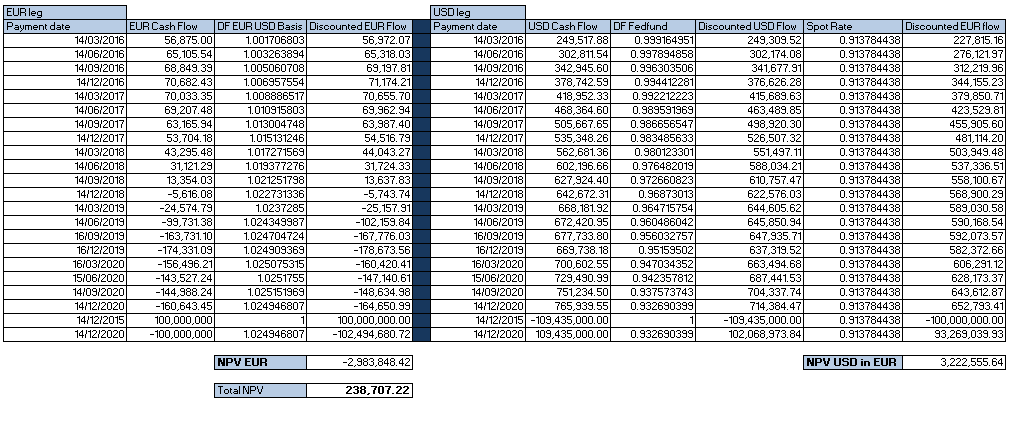
The spread on EUR floating leg is -0.1 and on USD floating leg is 0.4



Figure : EUR-USD Xccy trade definition

The system Date is **10/12/2015** and the first spot date for the FX rate is **14/12/2015**.

### NPV:



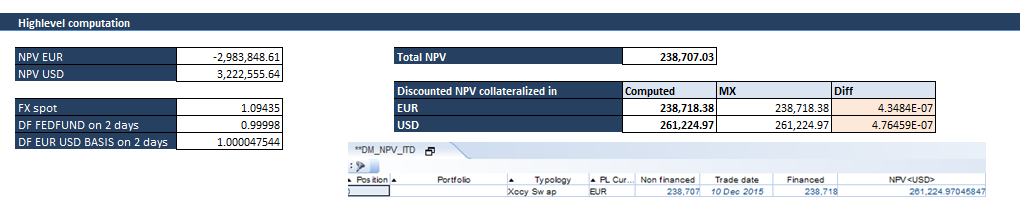
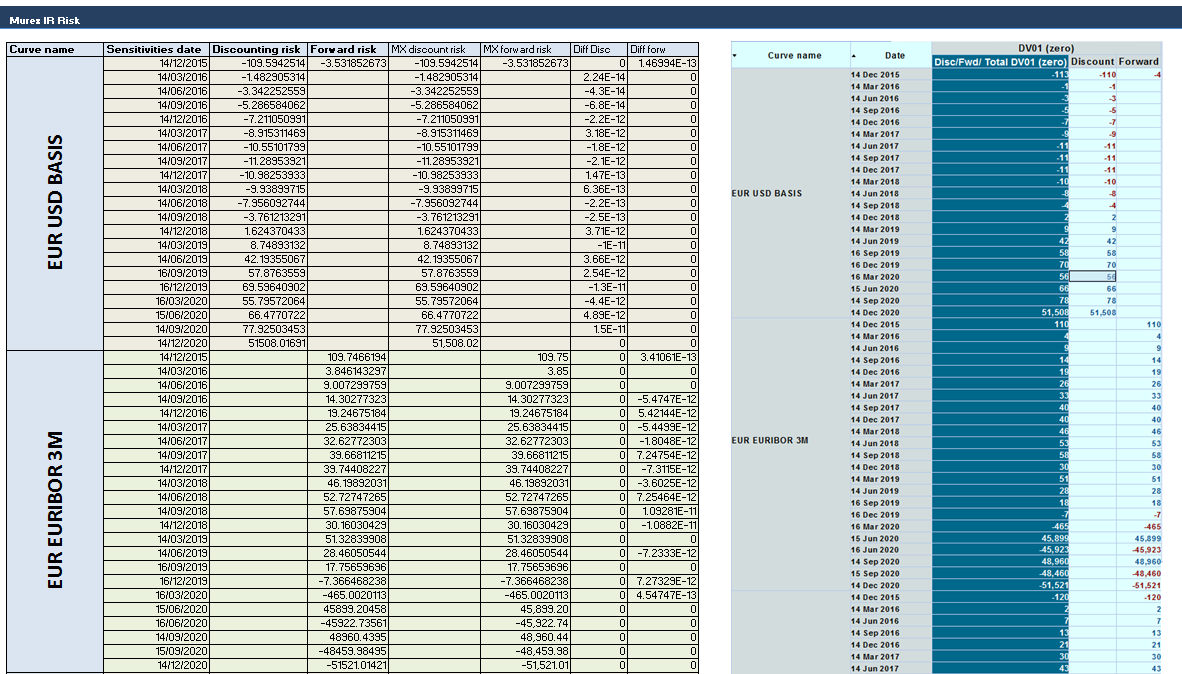


Figure : EUR-USD Xccy NPV matching results

### Total zero IR deltas:



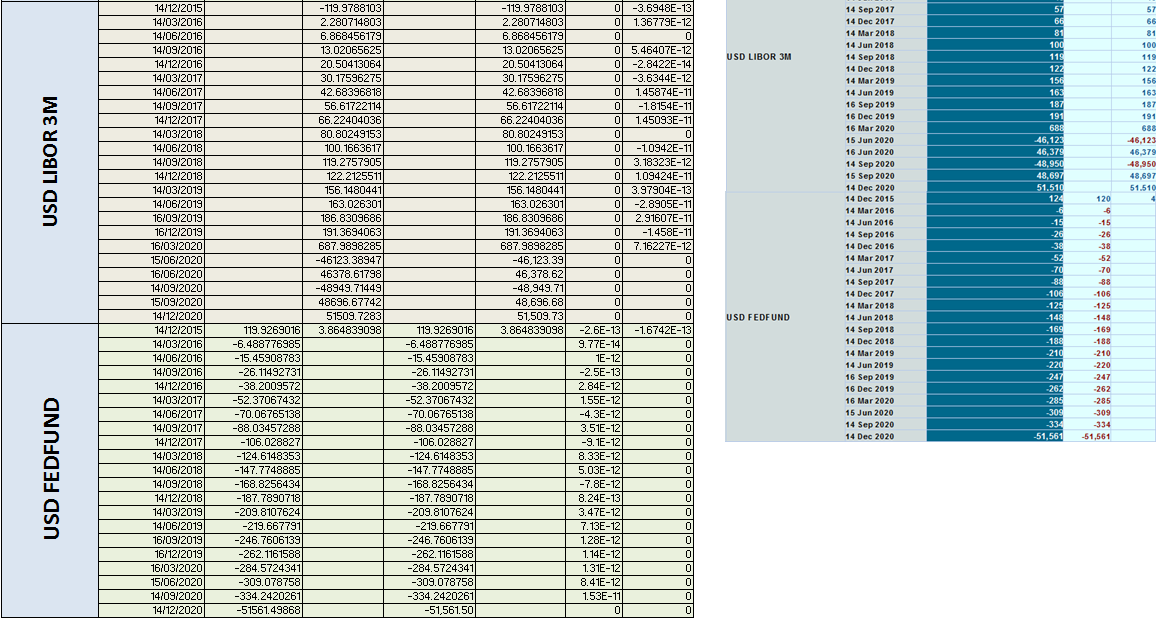


Figure : EUR-USD Xccy IR delta matching results

### FX spot conversion IR risk:

### 

Figure : EUR-USD Xccy FX spot conversion IR risk matching results

### FX delta:

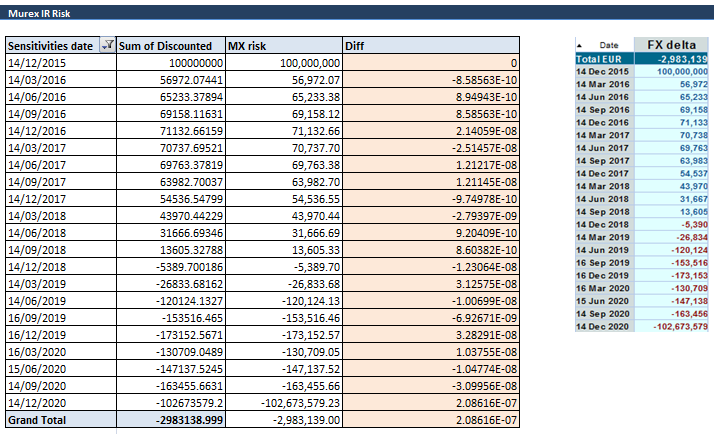


Figure : EUR-USD Xccy FX delta matching results

Figure : Total IR Risk

## Resettable cross currency basis swap

### Trade definition

The trade is priced considering its first cash flow (Nominal Exchange) starts at spot date.

The spread on EUR floating leg is -0.1 and on USD floating leg is 0.4

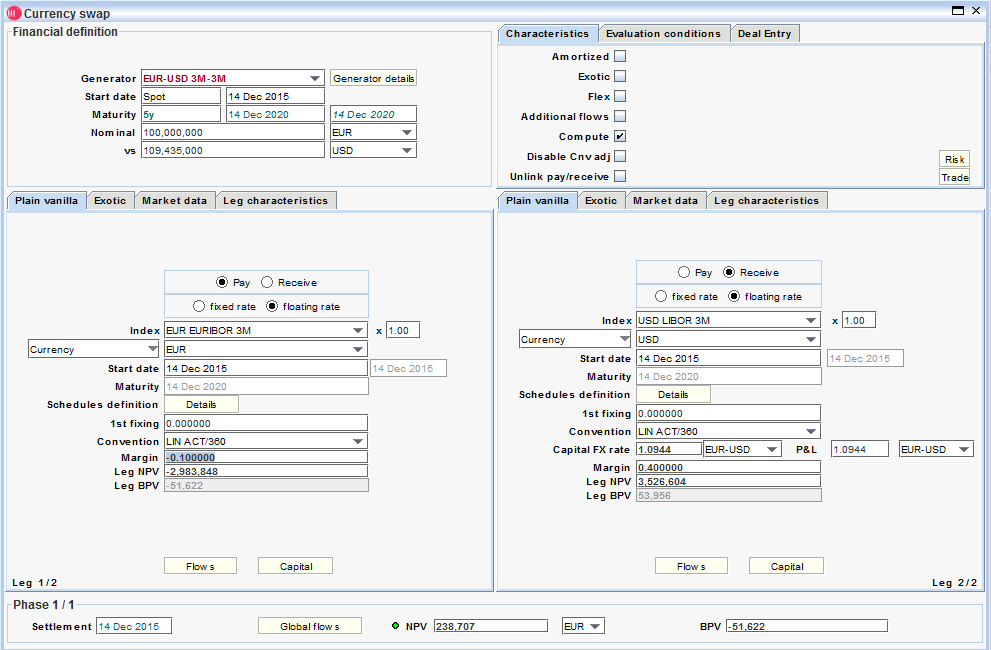
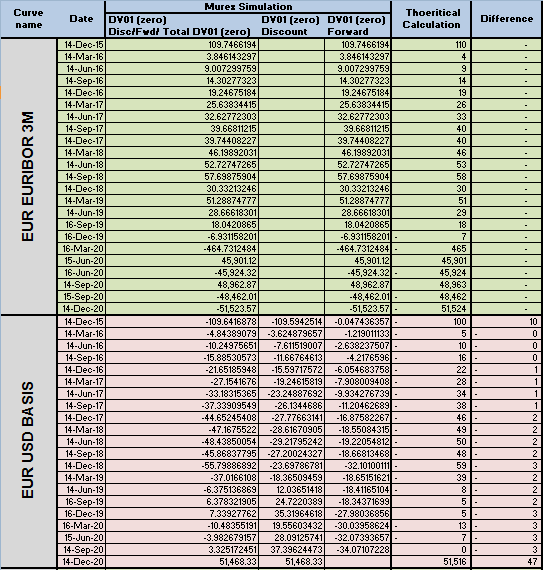


Figure : Resettable EUR-USD Xccy trade definition

The system Date is **10/12/2015** and the first spot date for the FX rate is **14/12/2015**.

### Total zero IR deltas:



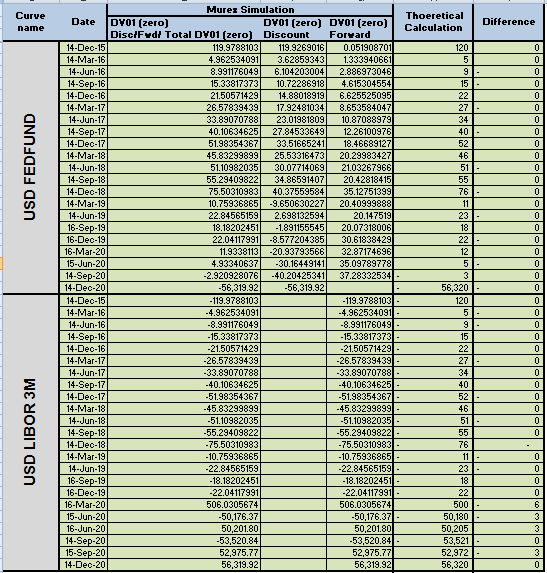


Figure : Resettable EUR-USD Xccy IR delta matching results

### FX delta:



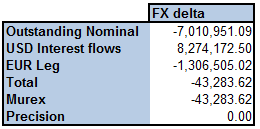


Figure : Resettable EUR-USD Xccy FX delta matching results

## EUR-USD resettable cross currency basis swap: NPV and Risk Post trade inception

### At the FX Reset Date

5Y resettable cross currency basis swap with 4Y remaining to trade’s expiry is priced in this exercise. The FX reset date is 10/12/16 in the current example. XCCS is priced before and after an FX fixing event and the risk behaviour will be checked.

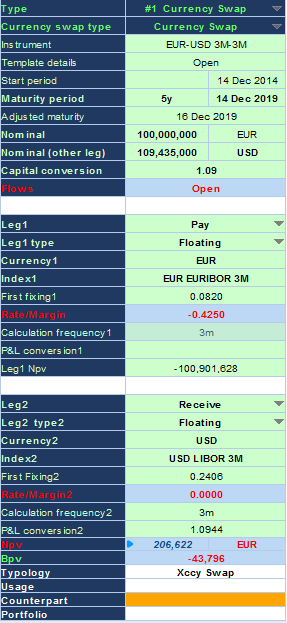
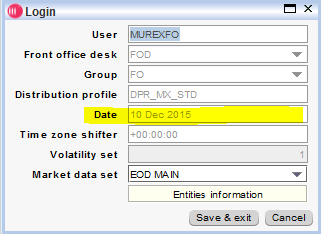


Figure : Resettable EUR-USD Xccy Trade definition

### Before FX fixing

* Fx delta from EUR Leg will be the NPV of the leg valued at spot date in EUR

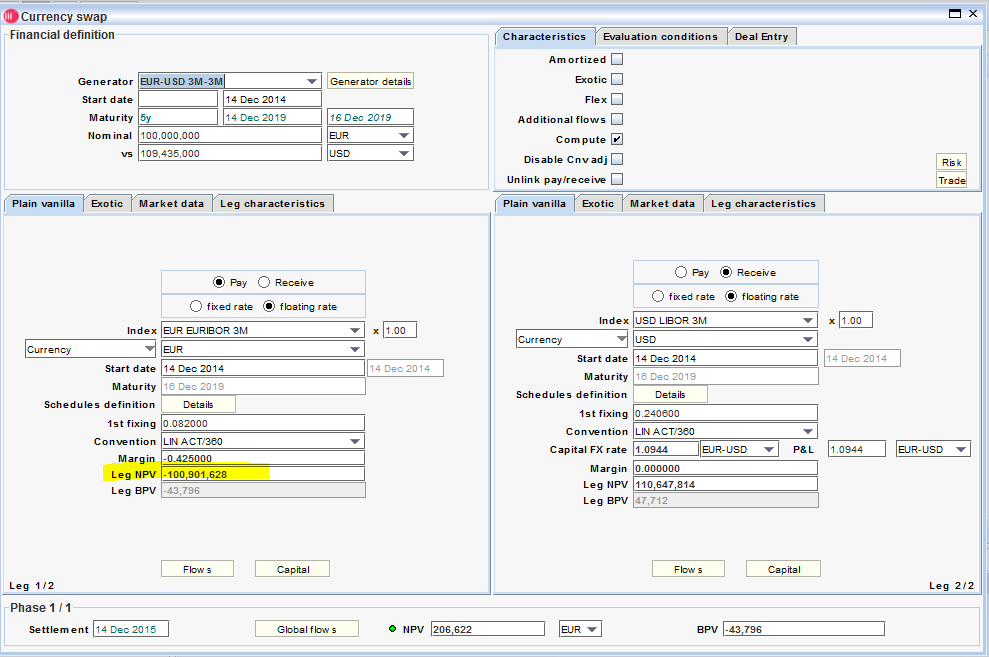


Figure : FX delta coming from EUR leg before FX fixing

* Fx delta of USD interest flows is the discounted flows at spot date converted to EUR using Fx spot rate

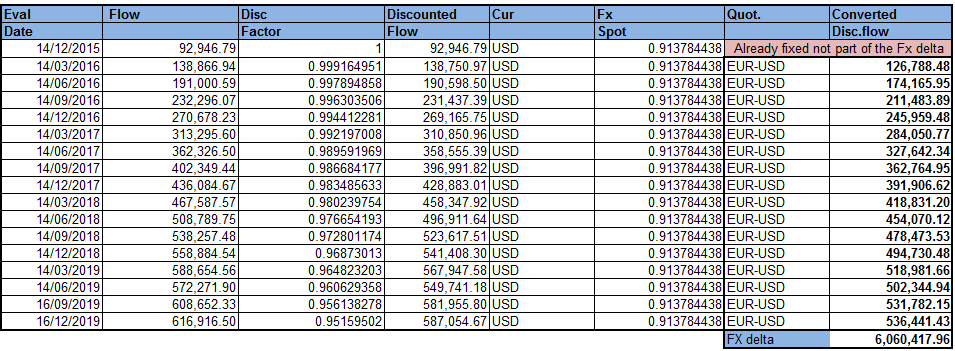
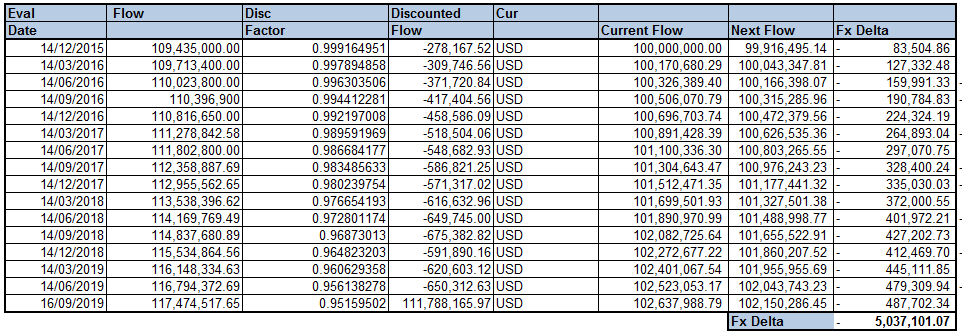
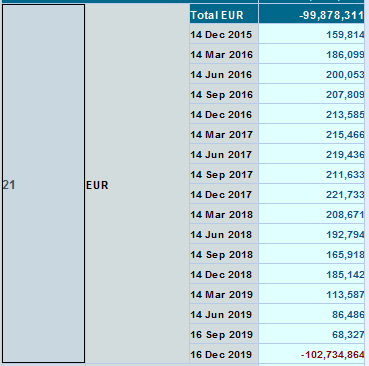


Figure : FX delta of USD interest flows before FX fixing

* Fx delta of USD outstanding capital is detailed below:



Figure : FX delta of USD outstanding capital before FX fixing

The total FX delta is still valid:

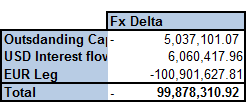


Figure : Total FX delta before FX fixing

### After an FX fixing

The EUR leg contribution will remain the same; however, we will remove the 14th December 2015 flows contributions from the USD leg contribution:

* USD interest flows

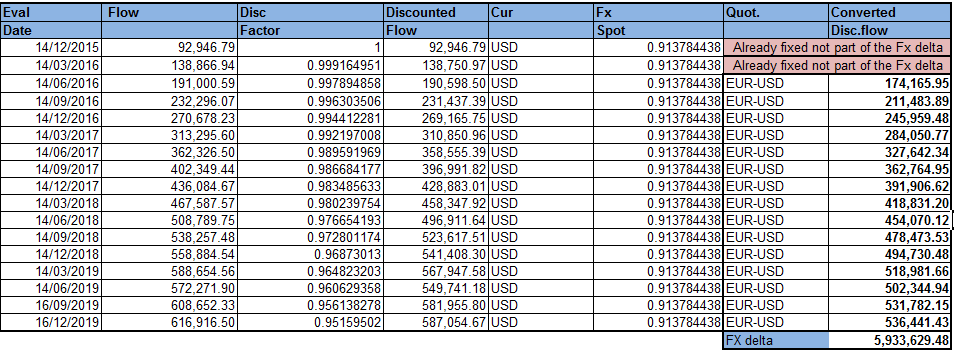


Figure : FX delta of USD interest flow after FX fixing

* Outstanding notional

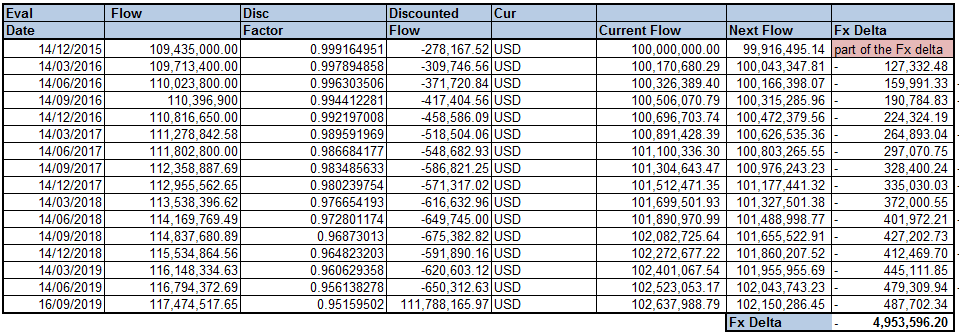


Figure : FX delta of USD outstanding capital after FX fixing

This is in line with Murex:



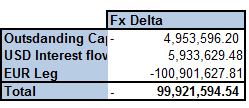


Figure : Total FX delta after FX fixing

### After an FX reset FX Date (2 days after the Notional exchange)

In this test case, 2 years resettable cross currency basis swap post first notional exchange is priced. The pricing date remains 10/12/16 and the first exchange nominal is 09/12/16 (past date). The deal’s flows is as following

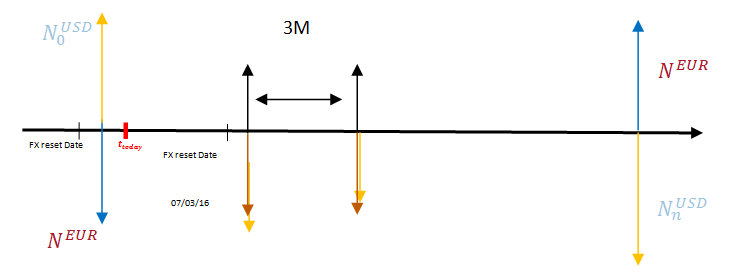


Figure : Cash flows representation after FX reset date

The deal ticket is as following:

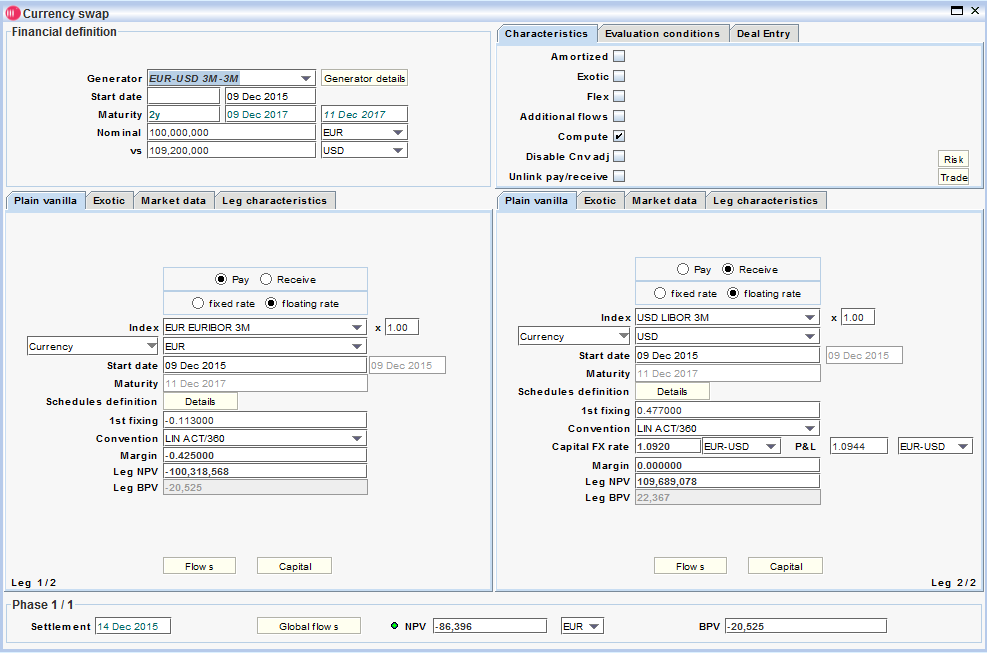


Figure : Deal ticket

Thus the FX delta is very high and the main contribution is from the EUR leg.

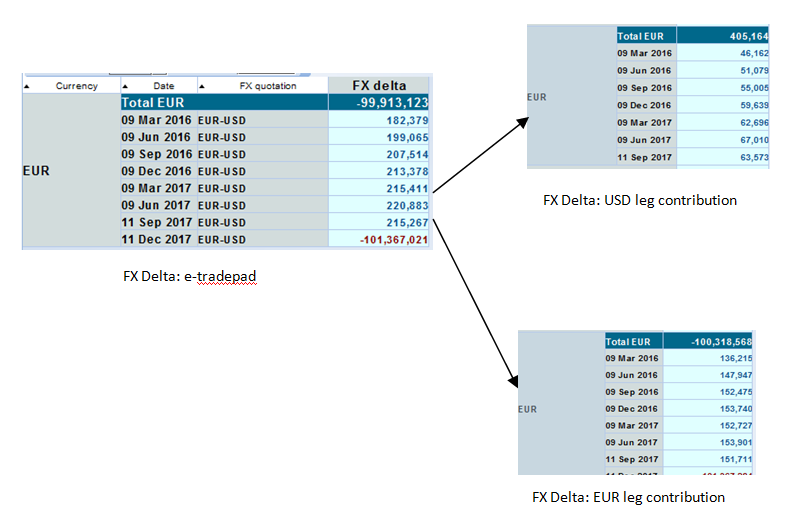


Figure : FX delta contribution after FX reset date

# Required MX configuration:

Several MX settings are required in order for Murex to reconcile the theoretical formulas in the current Murex version (v3.1.27), below main necessary configuration are listed:

## Basis curve as an outright curve:

As previously said Basis curves are outright curves and are not configured as spread on another curve. They calibrate zero coupons curve directly from its instruments. The “calibration” setting is hence set to “curve assignments”

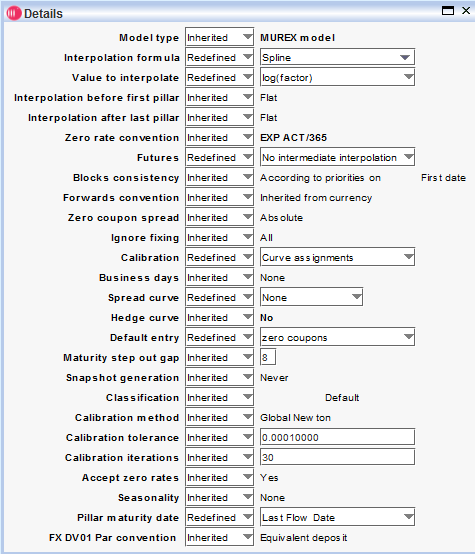


Figure : Basis curve settings

## FX cross sensitivities

FX cross sensitivities across currencies in the basis curve could be triggered via a “default entry” setting at the curve level:

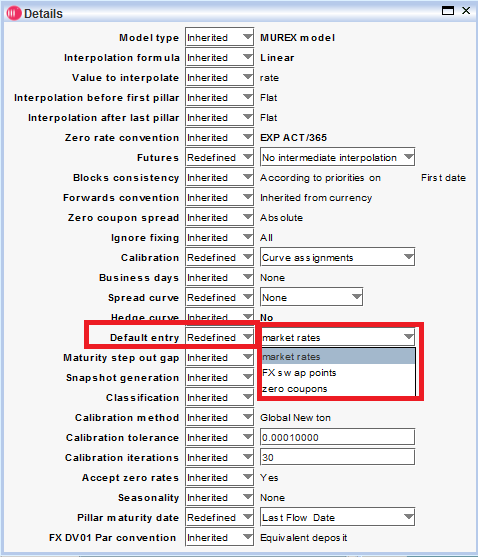


Figure : Default entry curve specific setting

The setting if set to “zero coupons” disables cross sensitivities. If it is set to “market rate” then the cross sensitivities will be calculated with respect to “keep market quotes constant” scenarios.

Generally speaking, the cross sensitivities will be defined as following:

=

This sensitivity will capture the recalibration effect of two dependent curves. In the EUR-USD resettable cross currency basis swap case, Murex will calculate the recalibration effects of USD Libor 3M and USD FedFund on the basis curve if the FX cross sensitivity calculation is activated. This is not in line with interest rate risk expected results

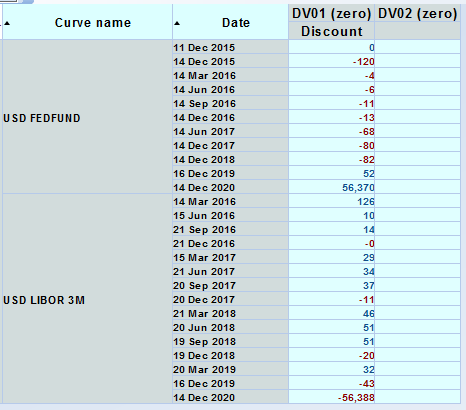


Figure : DV01 discounting risk projected on USD libor 3M due to cross senstivities

**FX cross sensitivities** should hence **not be triggered** and the setting **“default entry”** should be set to **“zero coupons”** in order to disable cross sensitivities computation.

## Rate/Rate propagation

The setting used in the default mode in Rate propagation.



Figure : Rate/Rate propagation setting

This means there is no cross effect calculated in delta (recalibration effect due to dual calls in curves). This was proven in the previous paragraphs.

As a reminder Murex proposes 3 propagation modes (used applied scenarios to the curves). These modes drive the recalibration of curves when a scenario is applied directly on the curve. It has also an impact of the delta calculation:

* Propagate zero coupon shifts (Default mode in v27 in LCH implementation): the zero coupon shift on a target curve will be applied on all curves of the same currency.
* Keep market quotes constant: When a curve is shifted, market quotes of other curves remain constant (a spread is computed at the level of the shifted curve to prevent other curves calibrating on the same tenors / instruments).
* Keep zero coupons constant: When a curve is shifted, zero coupons of dependent curves remain constant.

## FX router and FX curve assignments:

The FX index used in the XCCS is following the FX router assignments:

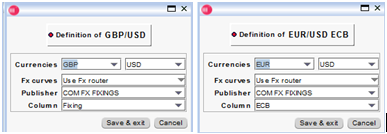


Figure : FX routers definition

The FX curves assignment:

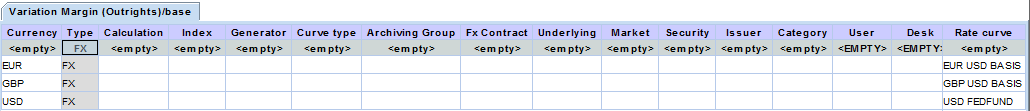


Figure : FX curves assignment

## FX conversion settings:

Two settings are needed in order to be able to convert today’s NPV from one currency to another using the discounted FX spot at the simulation level:

* “Spot conversion” flag set to “discounted” in FX general settings:

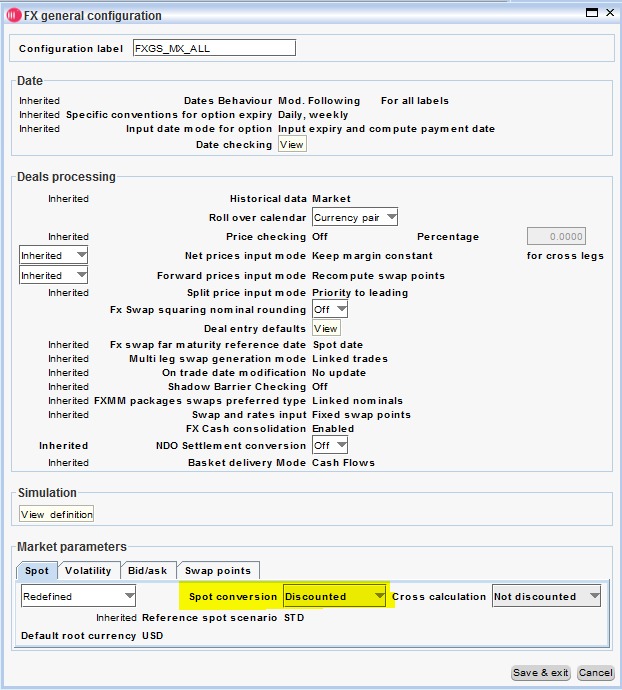


Figure : General FX setting of Spot conversion

* “FX spot conversion” set to “discounted” in the simulation setup screen:

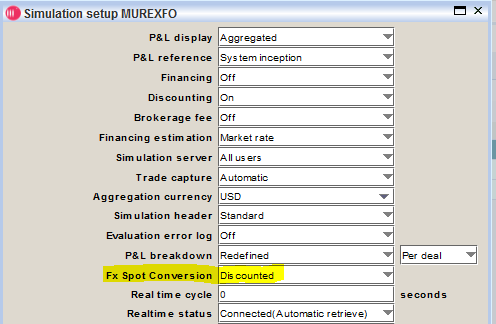


Figure : Simulation setting of FX spot conversion

Note that those settings do not impact the current official VM for current cleared Swapclear products. The FX conversion from local currency to GBP used to express the official figures of IM and VM is done outside of MX.3 pricing engine and is using the BAU risk validated FX spot rate.

It is worth to mention that for an accurate calculation, Risk change recommends using discounted FX spot instead of the FX Spot when calculating the VM and IM for members.

Finally, this means that a new workflow based on a “Simulation FX discounted spot conversion” might be necessary for cross currency basis swaps.

## FX delta- Simulation viewer output configuration

There is the possibility to define which currency is the non risky one. The FX delta will capture any NPV difference for any **FX spot** movement with respect to the non risky one. This is possible by setting the Family i.e. the leading currency to calculate the FX delta against:

The non risky currency is USD in the POC as cross currency basis swaps are collateralised in USD.

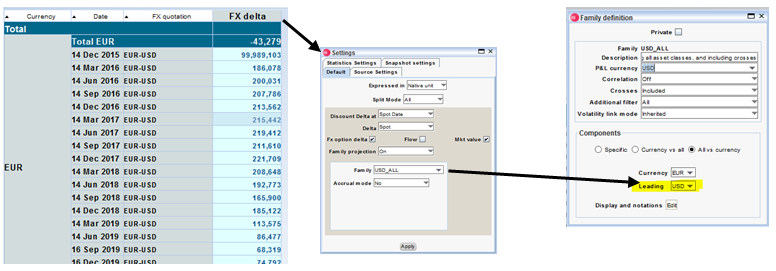


Figure : FX delta- Simulation viewer output configuration

There are two configurations in the simulation viewer to calculate the FX Delta. A daily PL selldown is supposed to take place or not depending on the “flow” setting in the simulation view:

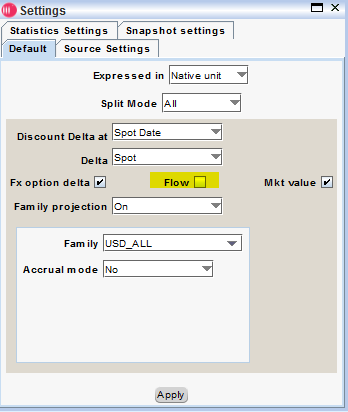


Figure : "Flow" setting

If flow setting is ticked, there is no PL selldown and thus the past cash flow in risky currency will be calculated in the FX delta (The cash flow is capitalised to today date).

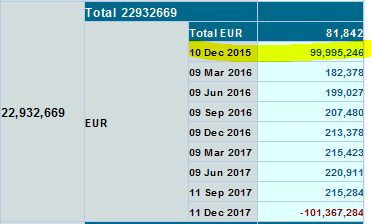


Figure : Past Cash is counted in FX delta

If the flag is un-ticked, then the FX delta will consider only MV in the calculation:



Figure : Only MV is considered in FX delta

The setting **“Flow”** box has to be **unselected** in the FX delta settings in order for the past cash not to contribute to FX delta.

# Gaps/ unexpected behaviours:

This section describes:

* Gaps found during the POC and confirmed by Murex support team.
* Unexpected behaviours found in Murex. LCH is waiting for an explanation from Murex (Configuration changes, workaround proposal, bug confirmation etc...)

## Gaps:

### “EUR: STD” curve:

“EUR: STD” curve appears in the “pop-up market data” even if it should not. This issue is considered by Murex as a bug and they confirmed that it is solved in higher version (V3.1.36). However, it is a non-issue as it is only a display issue; there are no side effects on curve calibration, product pricing or risk calculation. More detail in MX case **604023**.



Figure : Basis Curve - Wrong Dependency

### Basis’s curve Jacobean Matrix wrongly computed:

PAR interest rate risk is retrieved based on zero interest rate risk and basis curve’s Jacobean matrix following the below formula:

However, the figures of the Jacobean matrix are not as expected and unexplained. Depending on the basis curve constitution, the matrix Jacobean is weird, instable or wrong.

Murex has confirmed that there is a bug in v27 when a rate curve contains Swap points as pillars.

MX case **608605** has been raised to follow-up on this point.

The correction was provided in the patch 3.1.27.16.en.10. (See section 7.3 describing the validation of the fix)

## Unexpected behaviours:

### USD projected FX delta for GBP-EUR cross currency swap:

Expected FX deltas have been reconciled but expressed in the wrong outputs. Getting FX risk on different outputs should be taking into account when building the risk report in SwapAgent project. This will nullify the issue; however, MX case **614828** has been raised asking Murex for support.

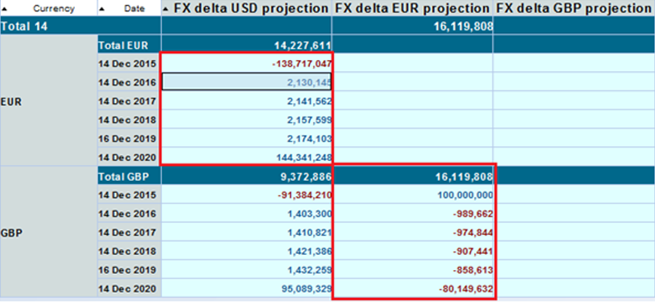


Figure : FX delta projected in two different outputs

### PL currency change not persistent at trade level:

It is not possible to express the PL Currency of a cross currency basis swap trade in a different currency than the base currency of the currency quotation (e.g. EUR is the base currency of EUR-USD currency quotation).

The only analytical figure impact spotted by this limitation at this stage is a mismatch between the expected FX spot conversion IR risk and the default Murex result. This mismatch can be ignored as it is very small.

MX case **616211** has been raised asking Murex for support.

# Patch 3.1.27.16.en.10 and corrections:

Murex provided the patch 3.1.27.16.en.10 that contains two major corrections for:

* Xccy basis curve jacobian and PV01 (6.1.2)
* Cross sensitivities in the simulation DV01 and PV01

The aim of section 7 is to not only to test the fixes but as well rerunning all the testing done previously in version 3.1.27.16.en.7 to verify that there is no regression.

Please note that the same Murex test environment has been used for the entire POC and was upgraded from version 3.1.27.16.en.7 to version 3.1.27.16.en.10.

## Settings and configuration

In addition to the required configuration listed in section 5, the below one are needed as well:

### Curves default entry setting

Any cross currency basis curve must have the setting “default entry” set to *market rates*:

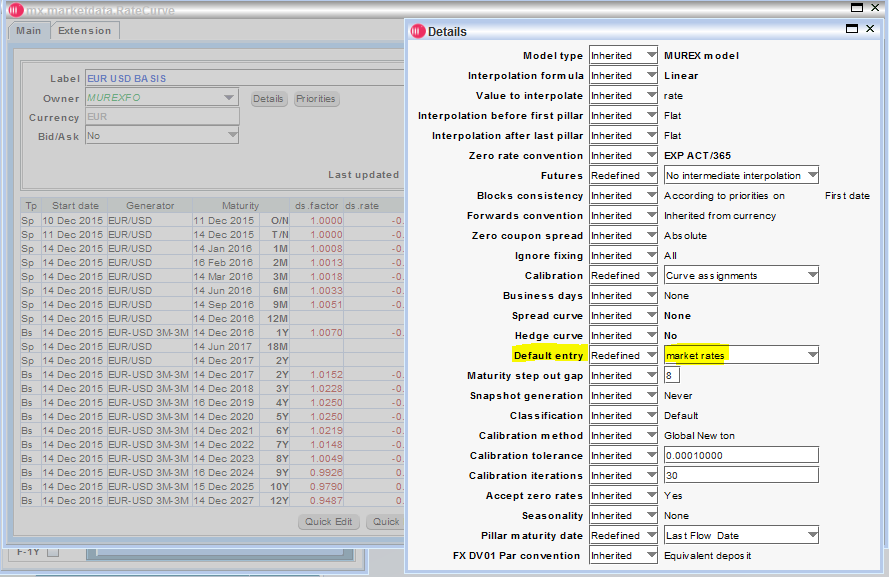


Figure : Default entry setting

### Slash /XCCY\_SENSIS\_FOLLOW\_PROPAGATION:

The slash **/XCCY\_SENSIS\_FOLLOW\_PROPAGATION:** is required in order to remove the not required cross sensitivity in the simulation risk figures for both DV01 and PV01.

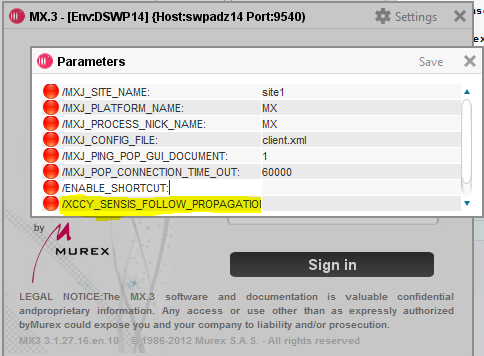


Figure : Slash /XCCY\_SENSIS\_FOLLOW\_PROPAGATION:

### “FX indexation evaluate using” setting:

The “FX indexation evaluate using” needs to be set to Quoted spot in order to have the fx forward used on the Xccy swap resettable leg calculated between spot date and forward shifter defined in the currency pair.

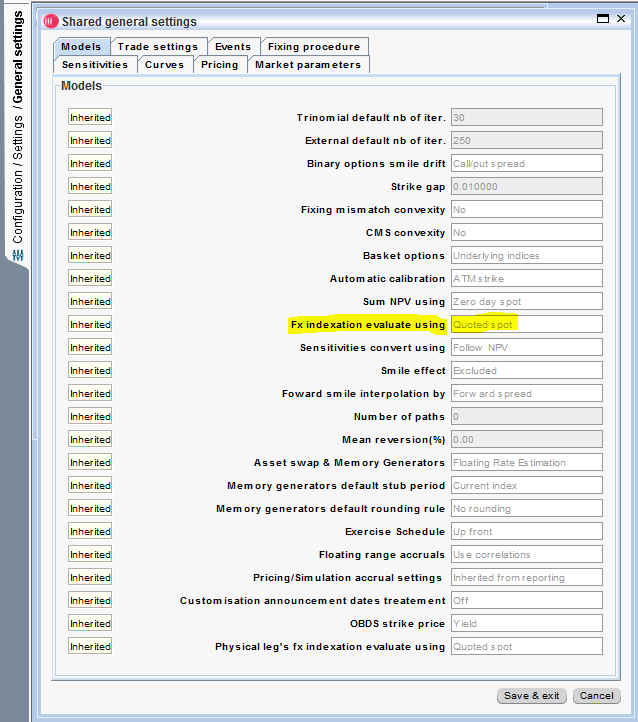


Figure : FX indexation evaluate using setting

FX indexation evaluate using:

* Quoted spot

The FX forward rate will be computed using the discount factors between spot date and fixing date + forward shifter defined in the currency pair.

* Zero-day spot

The FX forward rate will be computed using the discount factors between spot date and fixing date (no delay).

* Follow NPV

The FX forward rate will be computed using the discount factors between spot date and fixing date + forward shifter defined in the trade. Not recommended.

## Cross currency basis curve calibration

The curve EUR USD basis was kept the same and the calibrated zc with the new version- 3.1.27.16.en.10 -were compared with the previous obtained within 3.1.27.16.en.7.

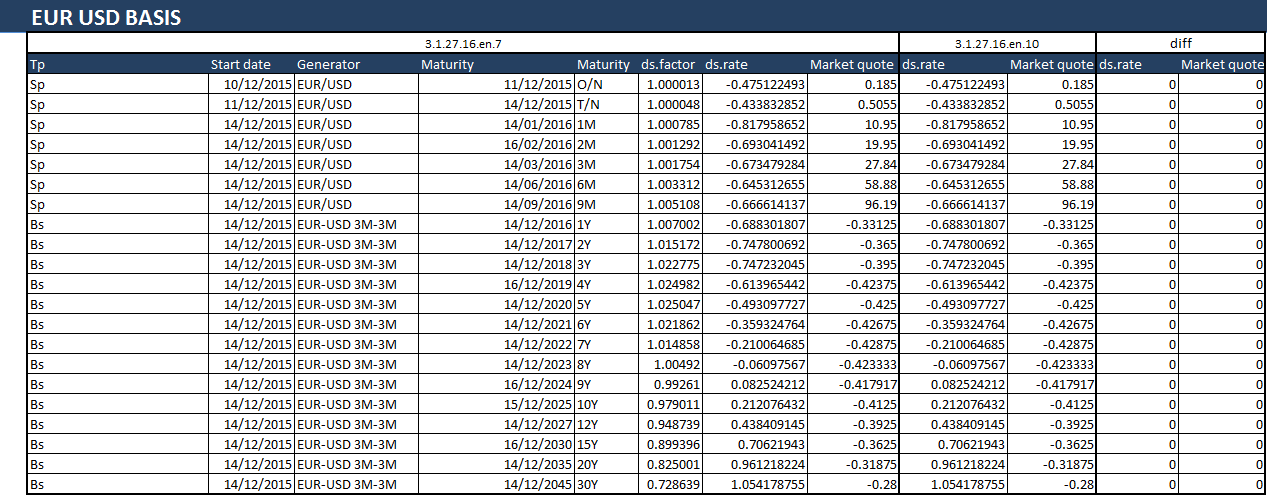


Figure : EUR USD BASIS calibration non regression matching results

Also some replication of the calibrated ZC and compared to Murex were done for some curve pillars.

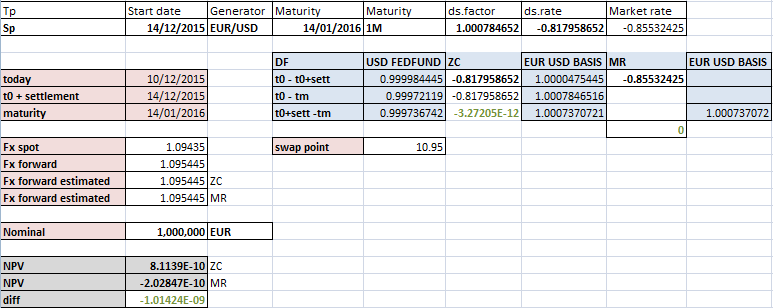


Figure : ZC replication for 1M pillar matching results

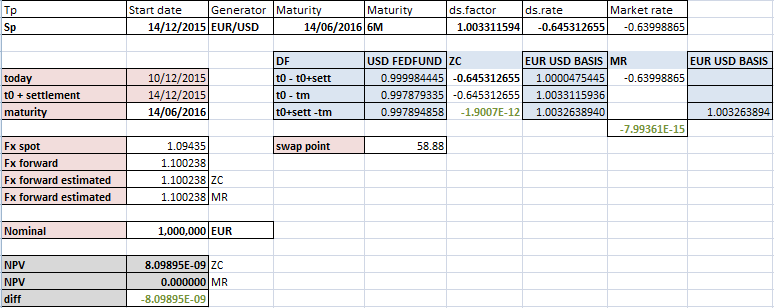


Figure : ZC replication for 6M pillar matching results

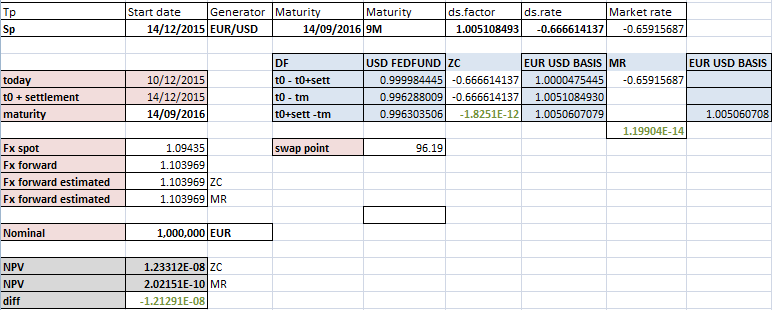


Figure : ZC replication for 9M pillar matching results

## Cross currency basis curve Jacobean

### Version 3.1.27.16.en.7 Jacobian issue

In this version, the Jacobian was wrong for the Swap point

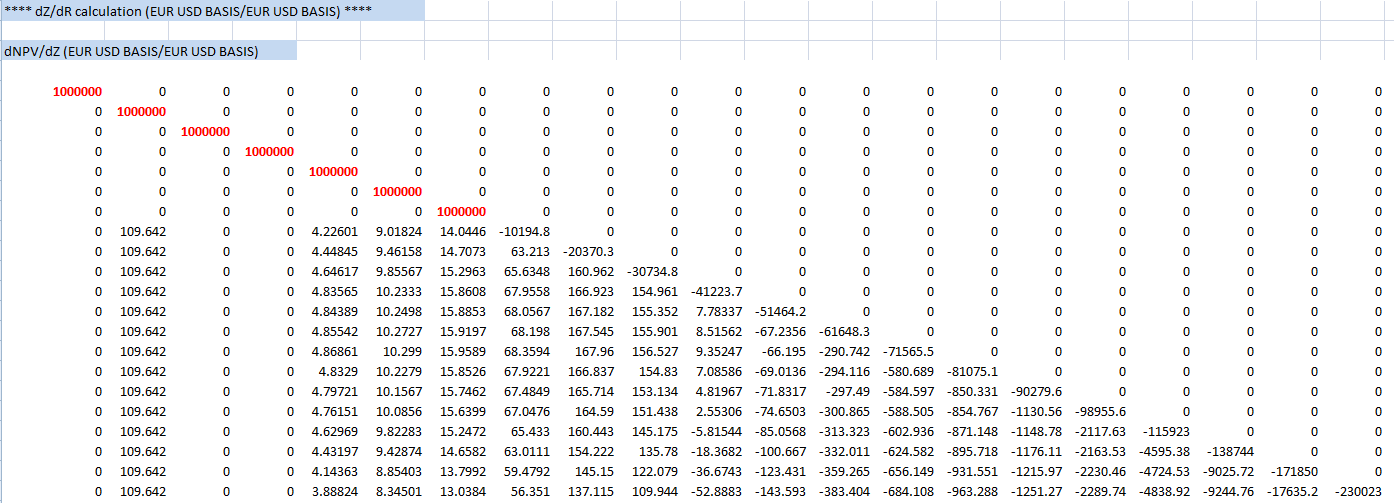


Figure : EUR USD BASIS dNPV/dZ Swap point issue

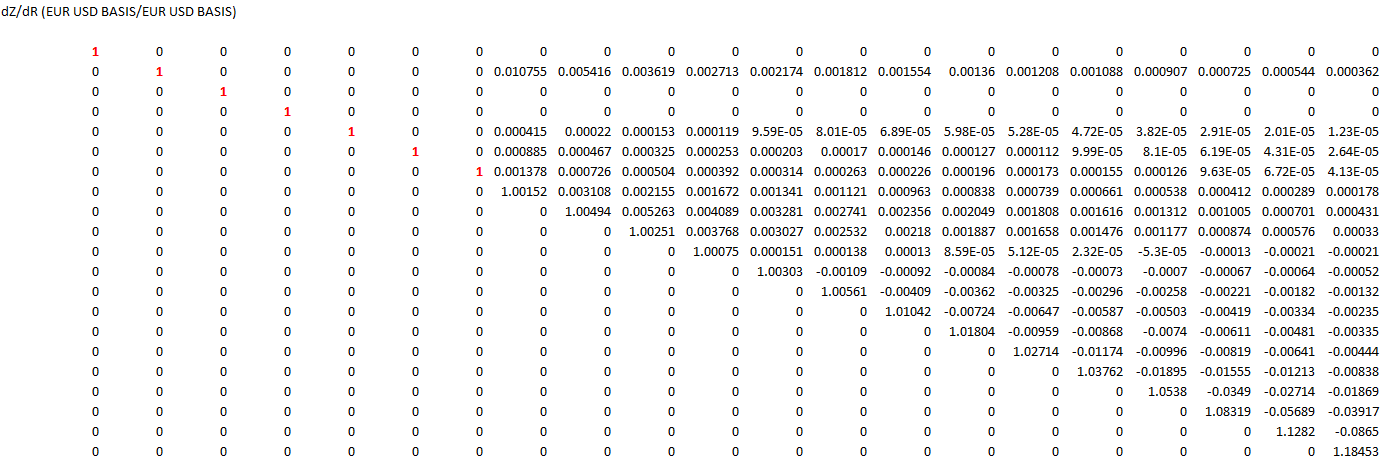


Figure : EUR USD BASIS dZ/dR Swap point issue

### Version 3.1.27.16.en.10 Jacobian correction

In the new patch 3.1.27.16.en.10 , the Jacobian was corrected as displayed below

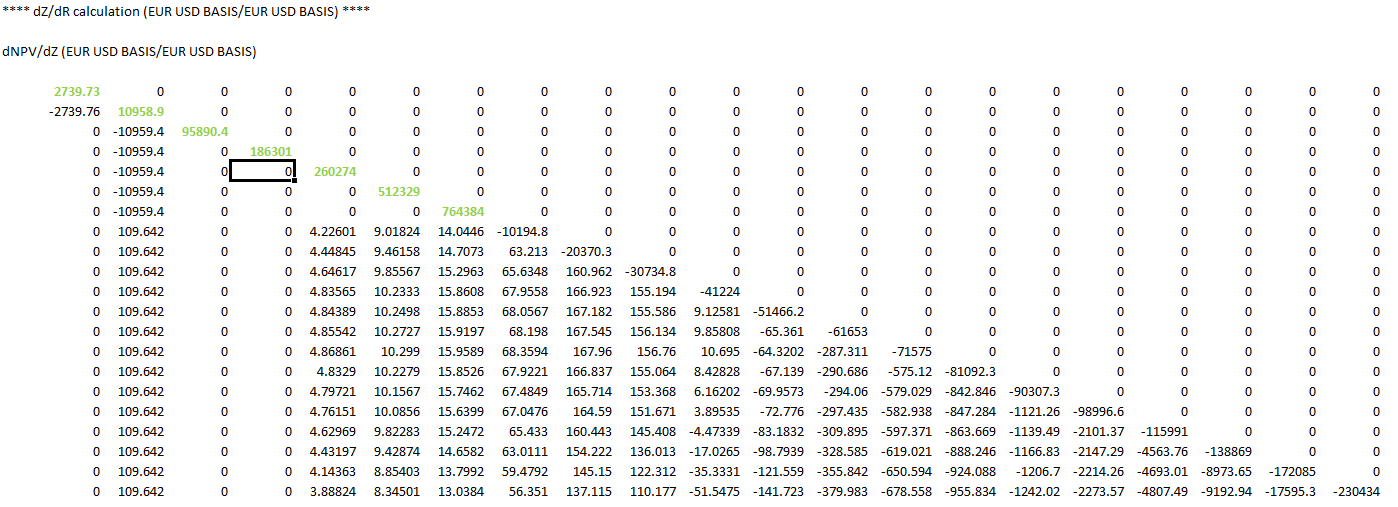


Figure : EUR USD BASIS dNPV/dZ Swap point correction

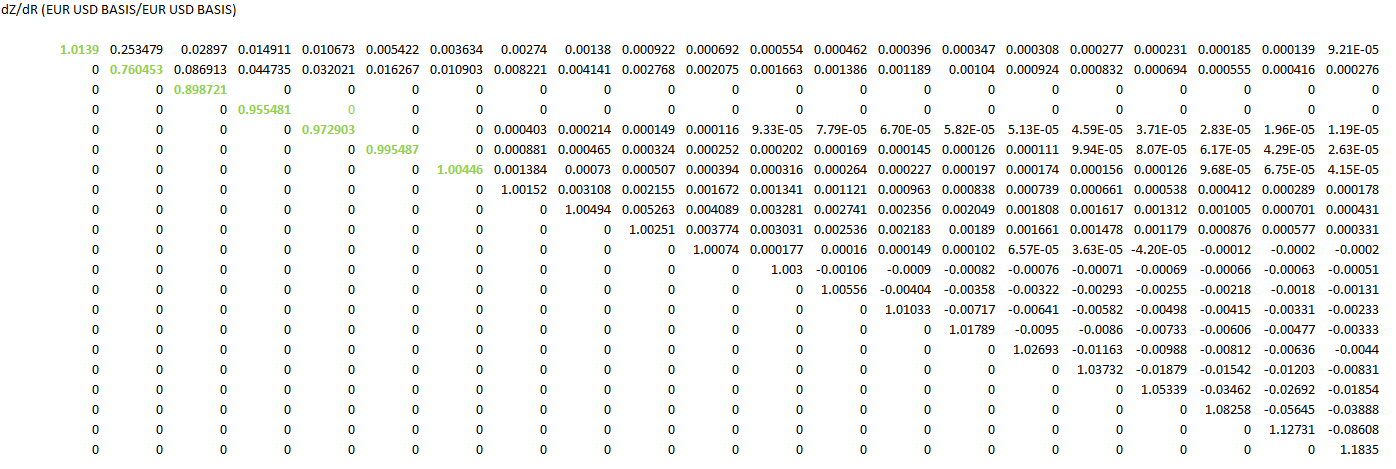


Figure : EUR USD BASIS dZ/dR Swap point correction

A replication of the Jacobian matrix was done as well for a Simplified EUR USD Basis curve containing only Swap points.

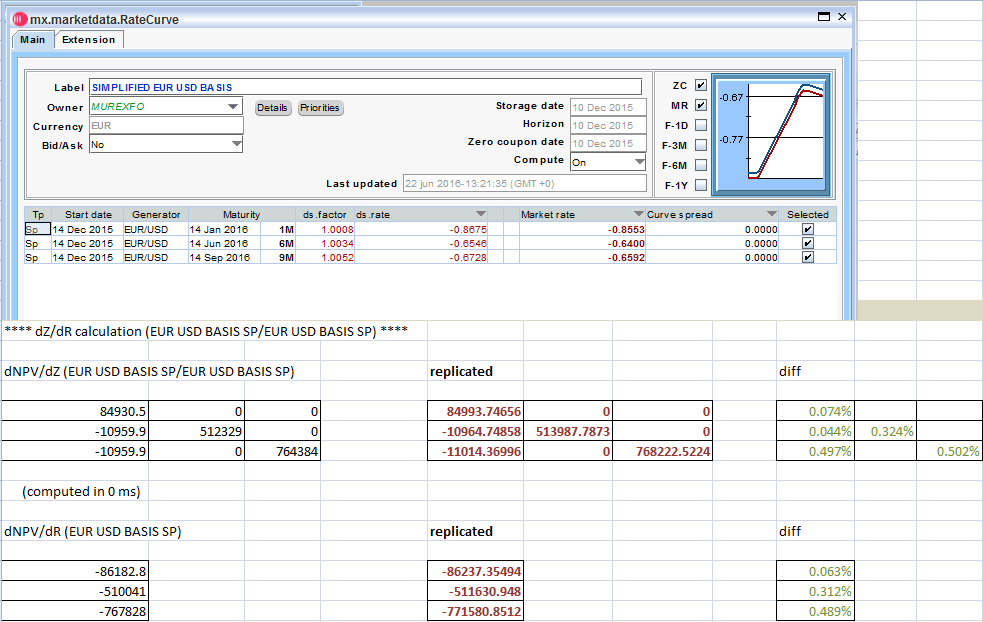


Figure : EUR USD BASIS Simplified curve Jacobian matching results

## Resettable cross currency basis swap (Float-Float)

### Trade definition

The trade is a EUR- USD 3M-3M resettable on the USD leg.

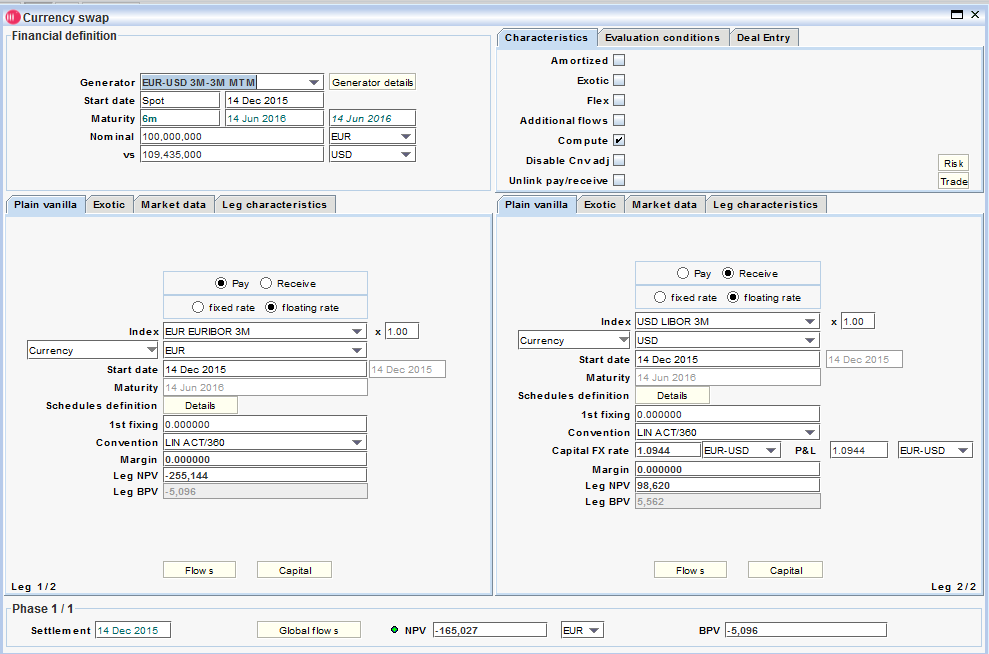


Figure : EUR-USD 3M-3M MTM trade definition

Trade date is 10/12/2015 and the first spot date FX rate is 14/12/2015

### NPV

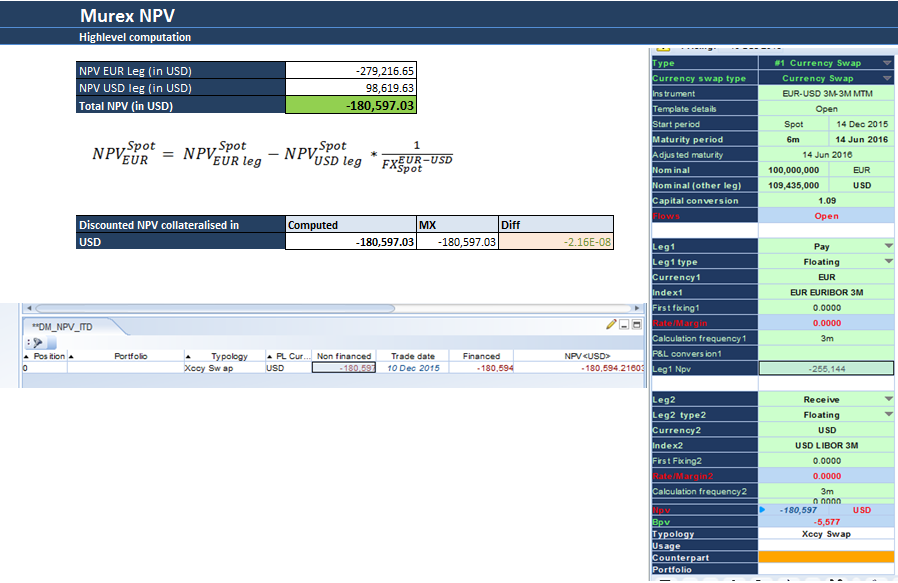


Figure : EUR-USD 3M-3M MTM NPV matching results

7.4.3 Discount IR risk EUR leg

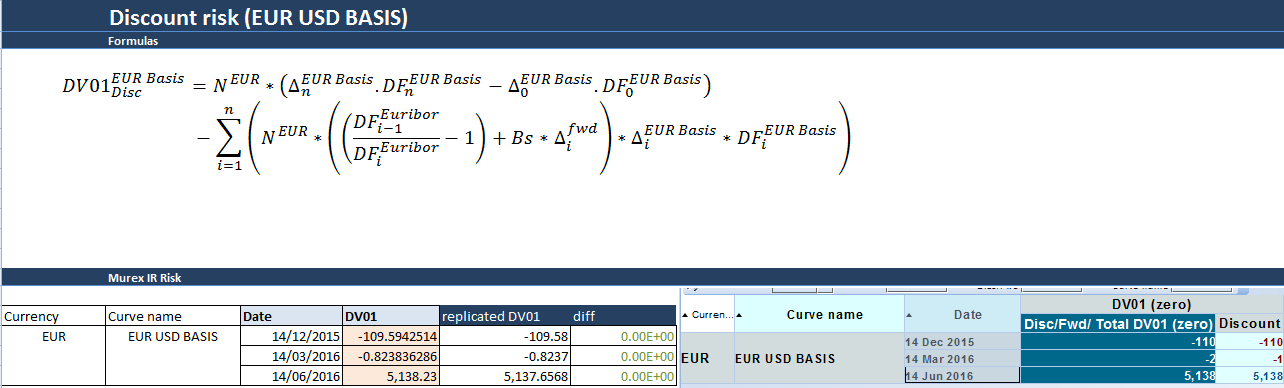


Figure : EUR-USD 3M-3M MTM Discount DV01 EUR leg matching results

7.4.4 Forward IR risk EUR leg

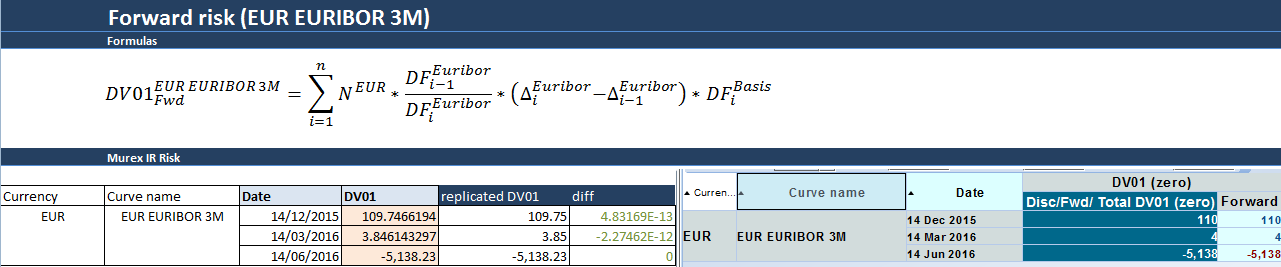


Figure : EUR-USD 3M-3M MTM Forward DV01 EUR leg matching results

7.4.5 FX spot conversion IR risk EUR leg

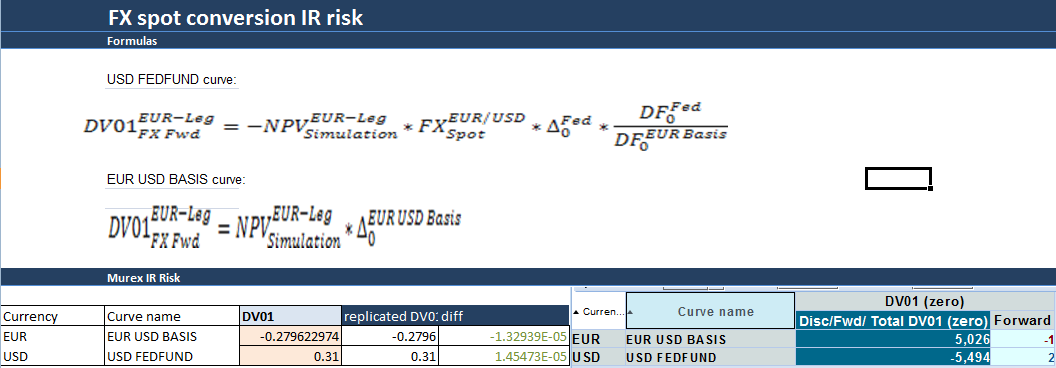


Figure : EUR-USD 3M-3M MTM FX spot conversion DV01 EUR leg matching results

7.4.6 Discount IR risk USD leg

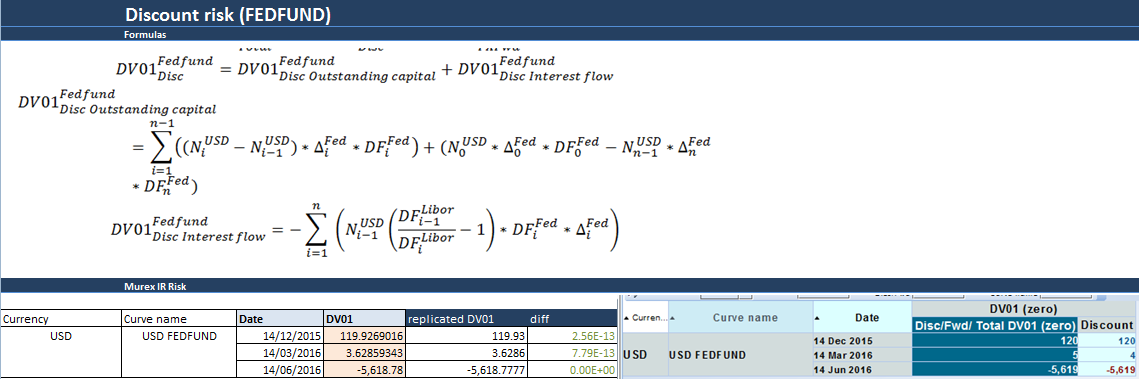


Figure : EUR-USD 3M-3M MTM Discount DV01 USD leg matching results

7.4.7 Forward IR Risk USD leg

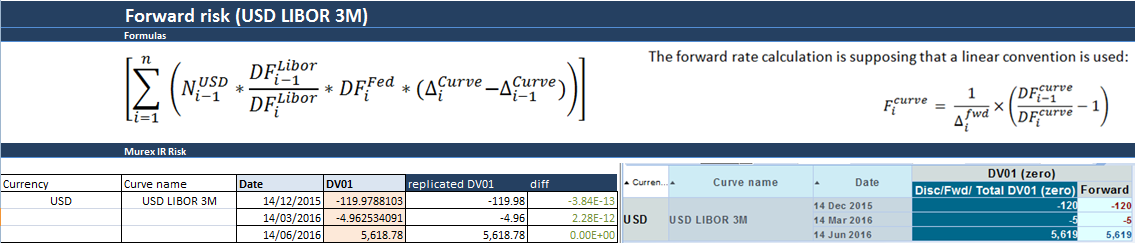


Figure : EUR-USD 3M-3M MTM Forward DV01 USD leg matching results

7.4.8 FX Fwd IR risk USD leg

Doing the comparison, we can see we are matching the sensitivities on all curves. There is a very small noise on EUR USD basis but it is very small to be ignored

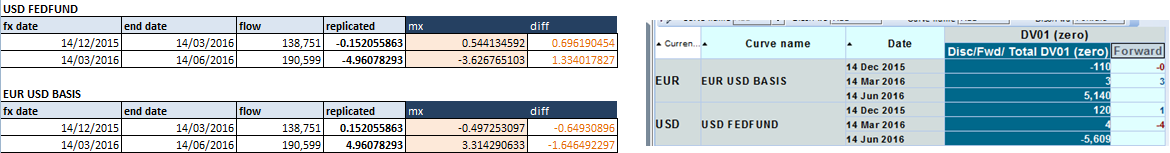


Figure : EUR-USD 3M-3M MTM FX Fwd DV01 USD leg matching results

7.4.9 PV01

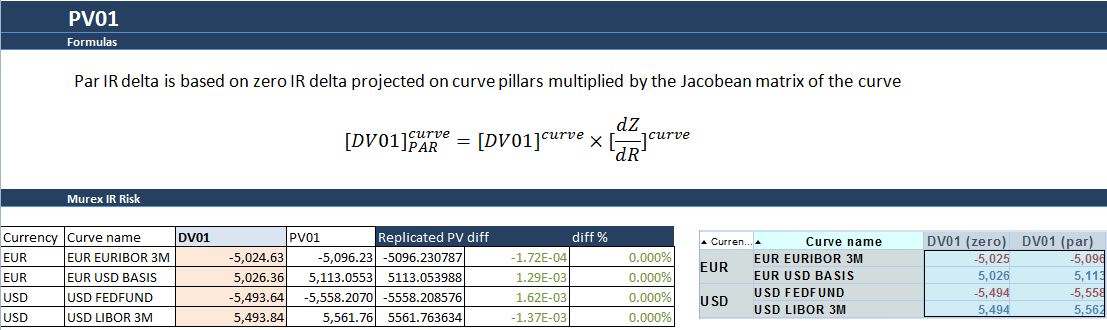


Figure : EUR-USD 3M-3M MTM PV01 matching results

7.4.10 FX delta EUR leg

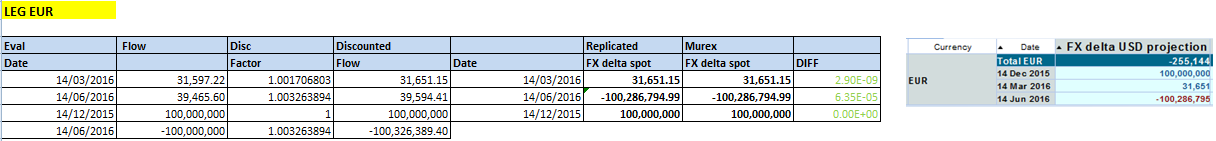


Figure : EUR-USD 3M-3M MTM FX delta EUR leg matching results

7.4.11 FX delta USD leg

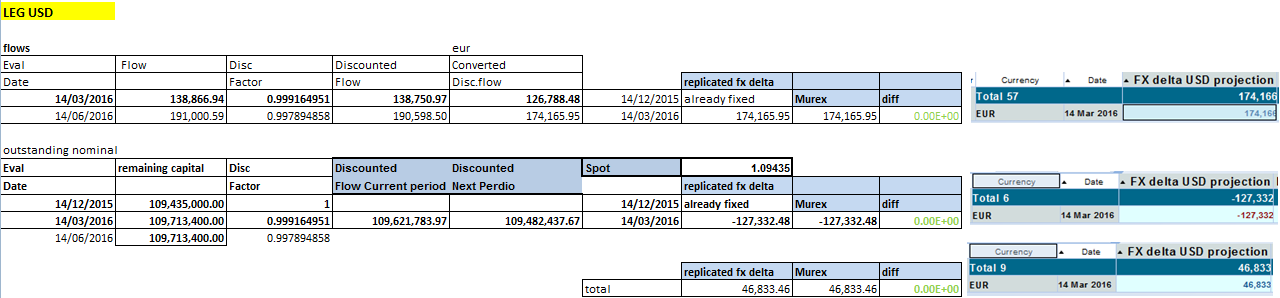


Figure : EUR-USD 3M-3M MTM FX delta USD leg matching results

## 7.5 Cross currency basis swap (Fix-Fix)

A non regression tests were done in 3.1.27.16.en.10 to check that case 4.1 has still the same NPV and risk figures as in version 3.1.27.16.en.7 .

7.5.1 NPV

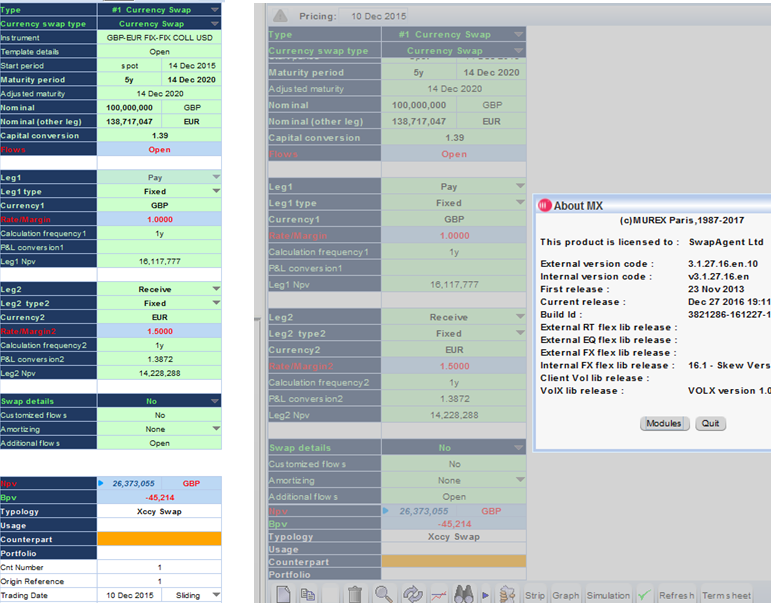


Figure : GBP-EUR FIX-FIX between versions NPV matching results

7.5.2 IR Risk



Figure : GBP-EUR FIX-FIX between versions DV01 EUR leg matching results



Figure : GBP-EUR FIX-FIX between versions DV01 USD leg matching results

7.5.3 FX delta

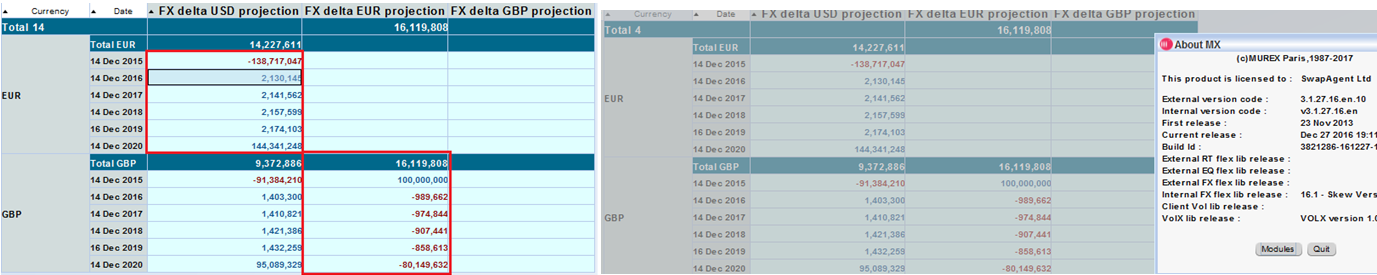


Figure : GBP-EUR FIX-FIX between versions FX delta matching results

## Non regression tests with the slash

**Previous configuration:** to avoid having cross sensitivities in the simulation risk figures, the “default entry setting” of the cross currency basis curve has to be set to *Zero coupon*- this solves the issue but this setting has to stay *market rates.*

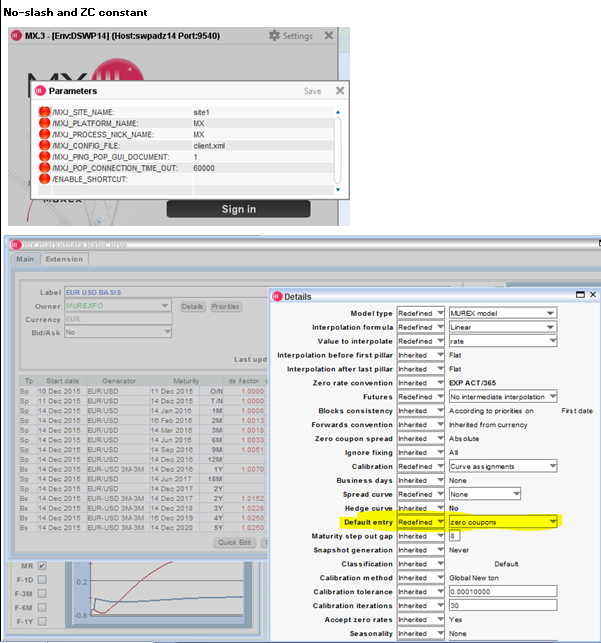


Figure : No-slash and default entry set to zero coupon

**New configuration:** In the version v3.1.27.16.en.10 thanks to the slash /XCCY\_SENSIS\_FOLLOW\_PROPAGATION:, the default entry setting can stay market rates and no cross sensitivity will be displayed in the simulation

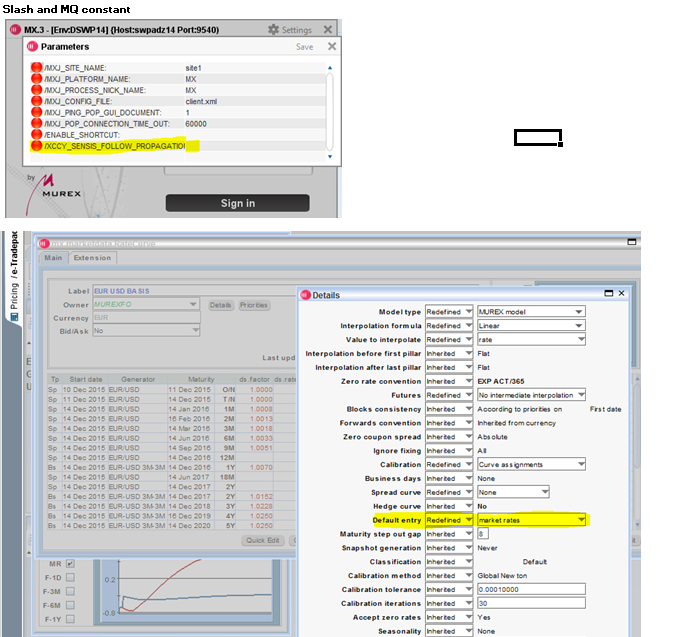


Figure : Slash and default entry set to market rates

### Results

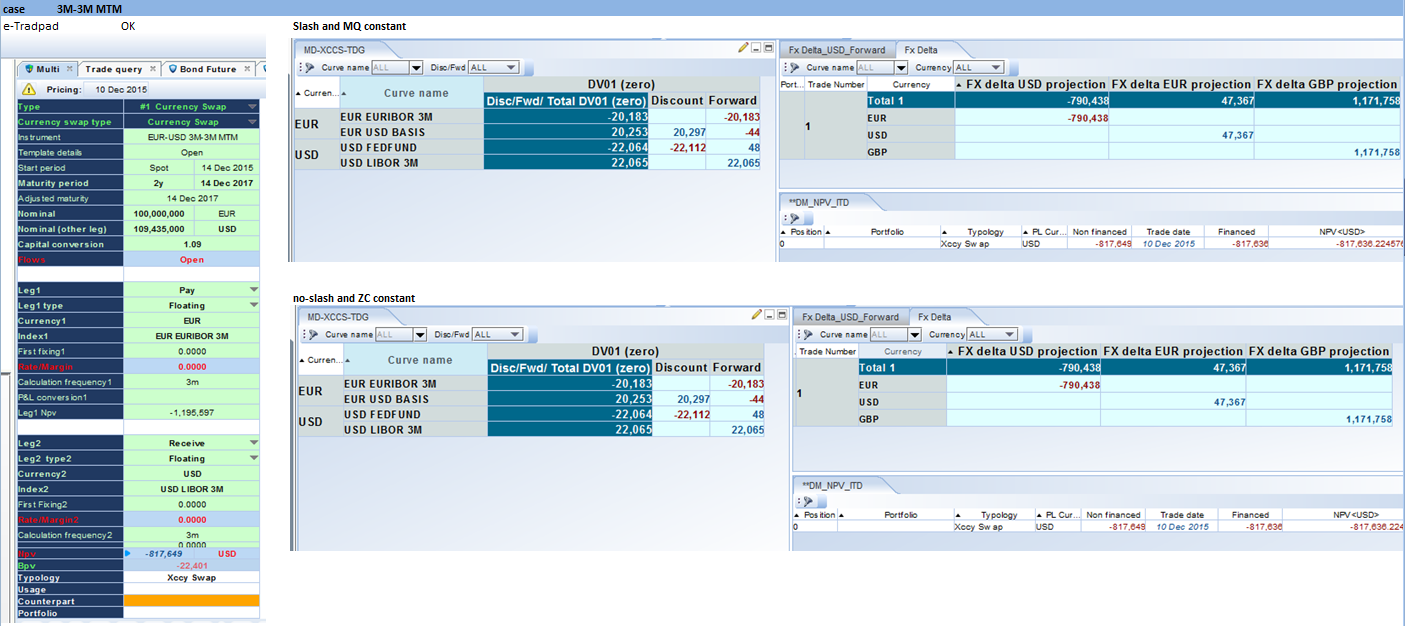


Figure : EUR-USD 3M-3M MTM with both settings configuration matching results

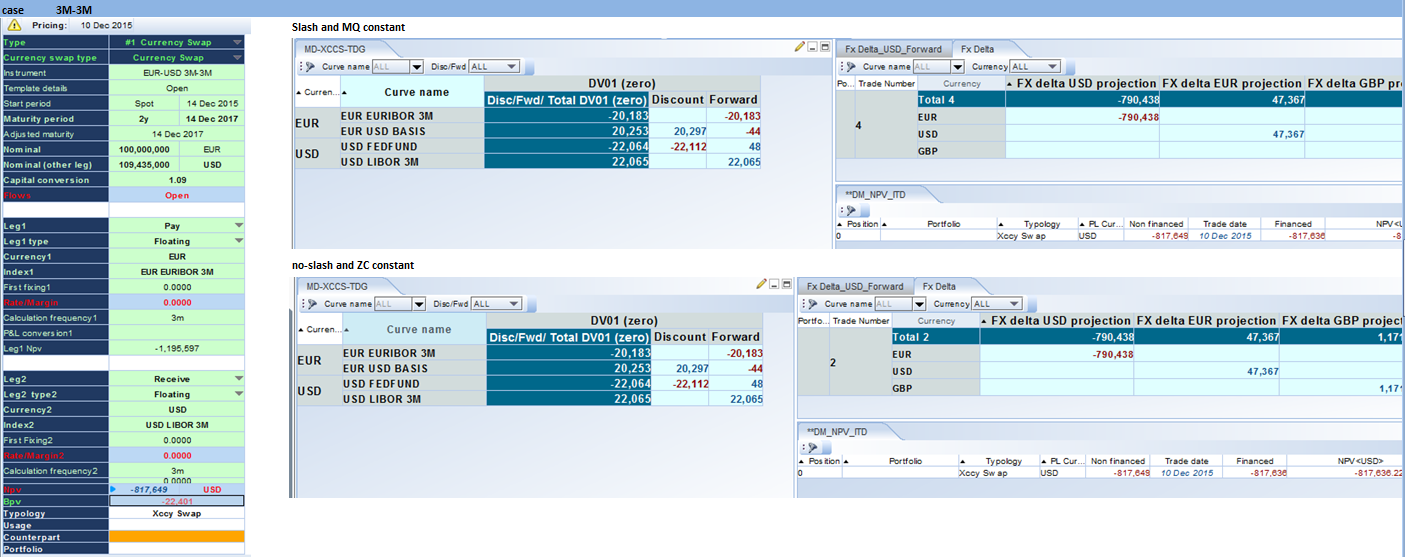


Figure : EUR-USD 3M-3M with both settings configuration matching results

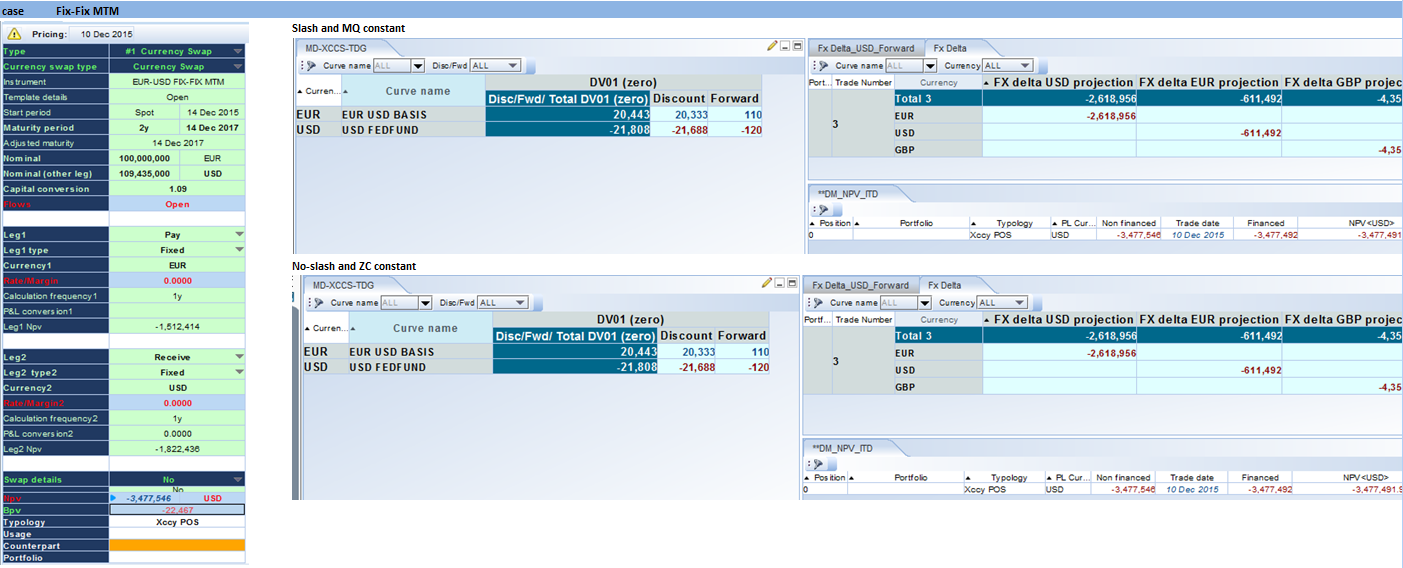


Figure : EUR-USD FIX-FIX MTM with both settings configuration matching results

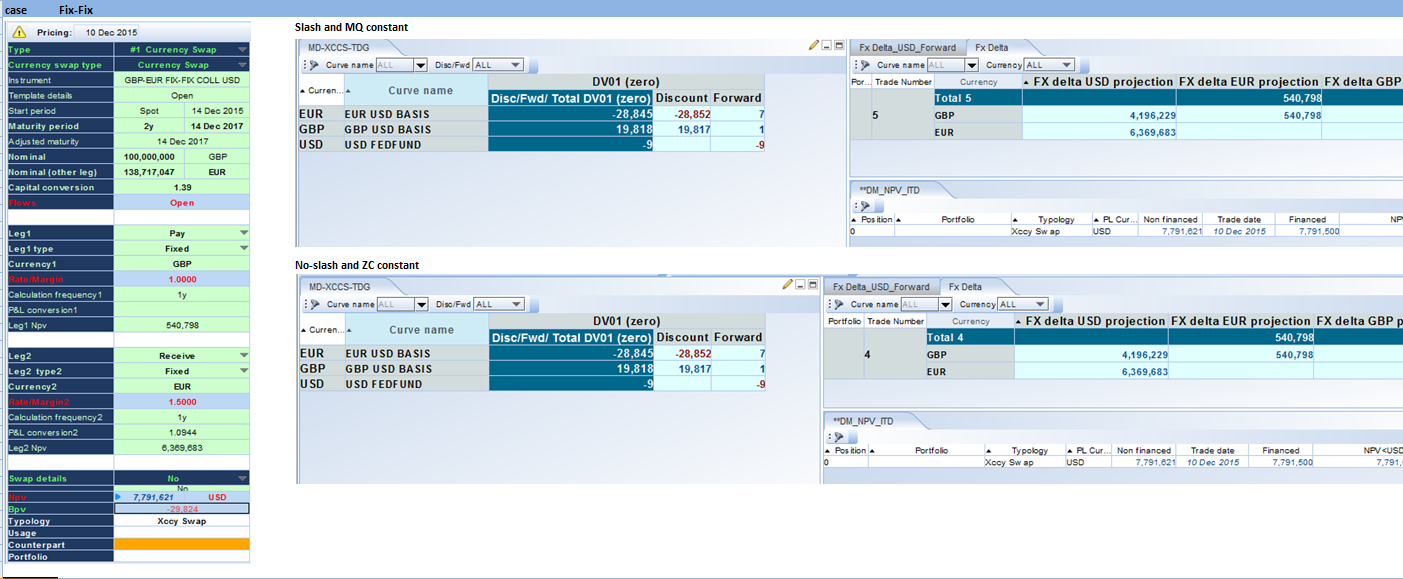


Figure : GBP-EUR FIX-FIX with both settings configuration matching results

# Appendix 1 – List of closed Murex cases

|  |  |  |  |
| --- | --- | --- | --- |
| **MX Case #** | **Severity** | **Description** | **Solution** |
| **592658** | **High** | XCCS: unexpected sensitivities on the libor curve | in v27, use default entry set to zero coupon in curve setting |
| **604055** | **High** | Top of Form  Fixing procedure not called at fixing date for FX  Bottom of Form | Solved using the PayFix Window script |
| **604053** | **Normal** | Several noises and new sensitivities dates in risk calculation | Extra DV01 risk was coming from cross currency cross sensitivities. Configuration change provided in #592658 solves this issue |
| **604023** | **Normal** | Xccs POC-STD curve called in Basis curve | This dependency is fixed in v36 but does not impact valuation and sensitivities |
| **611171** | **Low** | Collateral based discounting documents | Documents list provided |
| **596206** | **Low** | Xccy: Information request Murex Taylor VaR capabilities | Both option exists |
| Top of Form  **593134**  Bottom of Form | **Low** | FX delta: view configuration | No official document |

# Appendix 2 – Basis curve defined as a spread curve

Defining basis curves as spread curves over OIS curves is not considered in the scope. A test has however been done in order to check how the evaluation and the risks behave.

EUR-USD Basis curve has been defined as spread curve over EUR EONIA curve, instead of being an outright one.

The evaluation and FX delta does not change; below screenshots show IR risk comparison for the GBP-EUR Fixed-Fixed cross currency basis swap:

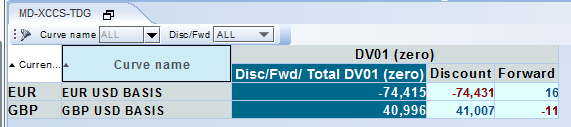


Figure : IR risk with basis curve defined as an outright curve

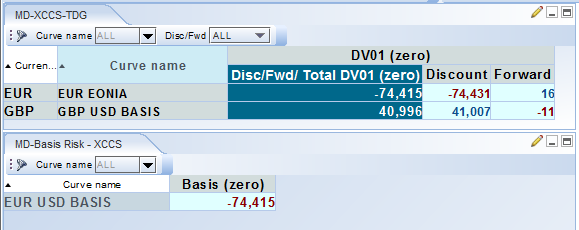


Figure : IR risk with basis curve defined as a spread curve

The IR discounting risk is the same and now projected on EUR EONIA, and a basis risk (or a spread risk) close to the IR discounting risk appears on the EUR USD Basis curve.