Circular C-IRS-08/2023

Valuation of IRS instruments

BME CLEARING

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Segment: IRS
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Replaces: C-IRS-06/2020

This circular defines the procedure for valuation of all transaction types of the OTC Interest Rate Derivatives Segment. Modified due to the discontinuation of the EONIA Benchmark

BME CLEARING will support the following financial instruments in the Euro currency (EUR), as detailed in Article B.3 of the General Conditions:

- Plain Vanilla Swaps
- Basis Swaps
- Zero Coupon Swaps
- Overnight Indexed Swaps (OIS)
- Forward Rate Agreement (FRA)

The valuation of the above instruments discounts each of the flows at present value. To do so, the following must be known:

- The valuation date or the date the present value of a flow is valued
- How the coupons are calculated. Calculation of coupons is defined in the Circular *Coupons, considerations and additional payments*.
- The implied or forward rates of floating reference rates for calculating the value of the legs linked to these reference rates.
    - BME CLEARING, as stipulated in the Circular *Curve Building*, calculates and publishes four zero rate curves on EURIBOR (1 Month, 3 Months, 6 Months and 12 Months) and one zero rate curve on EuroSTR. BME CLEARING also calculates and publishes the discount factors for these curves. The forward rate is obtained using the following formula:

$$P(t_2, t_j) = e^{-ZR_j * \partial(VD, t_j)}$$

$$f(t_j^S, t_j^E) = \left(\frac{P(VD, t_j^S)}{P(VD, t_j^E)} - 1\right) / \partial(t_j^S, t_j^E)$$

Where:

- The valuation date (VD) as the zero rate curve is
  - EuroSTR: Valuation date (VD).
  - EURIBOR: Valuation date (VD) plus 2 business day.
- $P(VD, t_j)$: Is the Discount Factor (DF) for the reference rate curve, of the date t_j referenced to *Valuation Date* (VD).
- ZR_j: Is the Zero Coupon Rate on ACT/365.
- $\partial(VD, t_j)$: The fraction of the year between dates VD and t_j. $\partial_i = \frac{t_j - VD}{365}$, for i from 1 to 50 years.
- $f(t_j^S, t_j^E)$: The implied Rate for the period t_j^S (Period Start Date) and t_j^E (Period End Date).
- *P* (VD,t_j^S): The Discount Factor (for the reference rate curve) of the date t_j^S (Period Start Date) referenced to the Valuation Date (VD).
- *P* (VD,t_j^E): The Discount Factor (for the reference rate curve) of the date t_j^E (Period End Date) referenced to the Valuation Date (VD).
- $\partial(t_j^S, t_j^E)$ The fraction of the year between dates t_j^S and t_j^S. $\partial_i = \frac{t_j^E - t_j^S}{360}$, for i from 1 to 50 years.
  - BME CLEARING publishes, in each curve, at least the points of each tenor that has a market rate used for building the curve, according to the Circular *Curve Building*. To obtain the implied rate of non-published tenors, a linear interpolation is made of the Zero Rates of the zero rate curve.
- Discount factors: BME CLEARING uses the discount factor curve from EuroSTR for the valuation of all its IRS Segment products.
  - BME CLEARING publishes the discount actors for each zero rate curve. Each tenor published matches the tenor of a zero rate curve. To obtain the discount factor of non-published tenors, a linear interpolation is made of the published Zero Rates of the zero rate curve.
- The formulas for each financial instrument, as specified in this Circular.

1. Flows of a swap

All swaps valued at par (or at market value) must have a Net Present Value (NPV) of zero. That is, the sum of the discounted flows at present value of both legs must be the same. Given that one leg is paid and the other received, these present values offset one another to zero.

Swaps may have two types of flow, where the implied interest rates are obtained according to the following rules:

1. **Regular**: Corresponds to the frequency of the index or reference rate of the agreed trade. For this type of flow applies the implied rate calculation period. When you do not have an implied rate of market (because the coupon date of the reporting period does not coincide with any of the published time), the implied rate is obtained via linear interpolation of the Zero Rates of zero rate curve, interpolating between the rates of the curve tenors encompassing the regular coupon.

2. **Irregular:** Occurs in a period at the beginning or end of life of the agreed trade, known as Stub period, which differs from regular period defined by the frequency of the index or reference rate. The duration of the stub period at the beginning or at the end may not exceed one year.

    a. **Flow at the beginning** of the agreed trade**.** The interest rate applied is defined by the counterparts and could be:

        i. A reference Fixing (1W, 1M, , 3M, 6M, and 12M)..

            - In the case of a EuroSTR Overnight Index Swap the reference fixing is EuroSTR.

        ii. The result of linear interpolation between 2 Fixings reference closest to the stub period (1W, 1M, 3M, 6M, and 12M). In the case of an Overnight Index Swap interpolation does not apply.

    b. **Flow at the end** of the agreed trade**.** The interest rate applied is defined by the counterparties and could be:

        i. The implicit rate of the reference curves (1M, 3M, 6M and 12M).
        ii. The result of linear interpolation on zero rate between 2 reference curves closest to the stub period (1M, 3M, 6M and 12M).

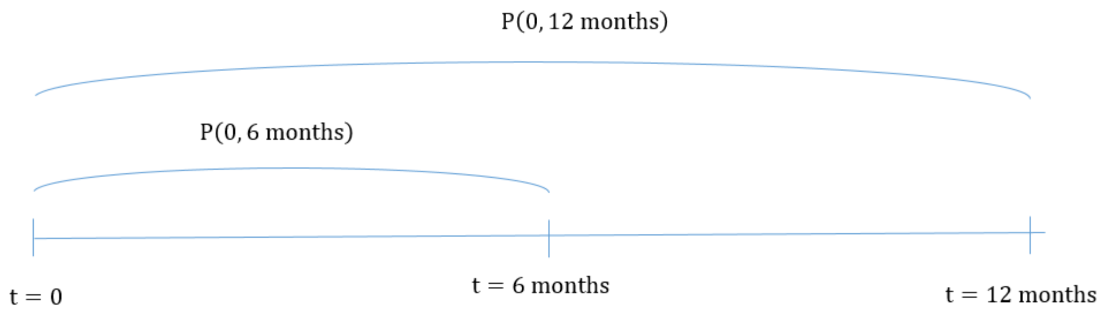
    c. **Flow Forward Start**, the implicit rate is obtained in the same way that as in paragraph b.

        In the case of a EuroSTR Overnight Index Swap the rate is referenced to EuroSTR.

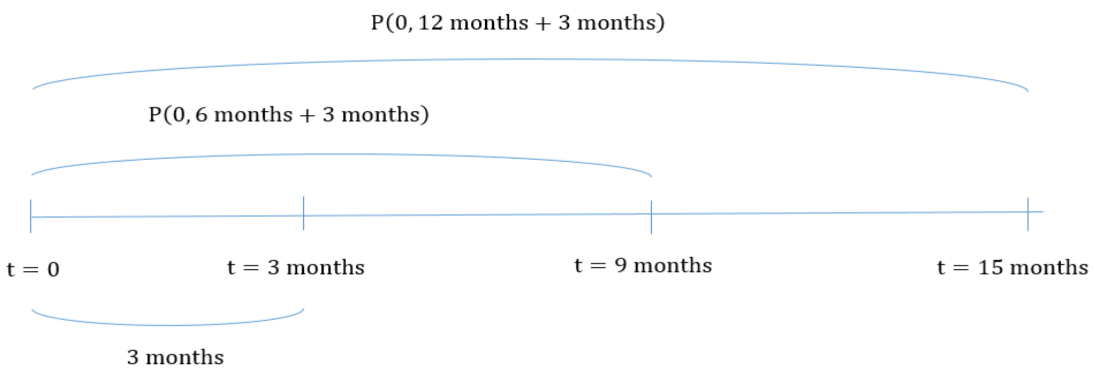
The frequency of settlement of flows from the two legs need not coincide. That is, a leg may pay flows on an annual basis, and the other on a quarterly basis.

The value date of a swap is, by market convention, 2 business days following the trade date. However, this value date may be longer, thus giving rise to a Forward Start Swap, and it is applicable to any swap defined in point 4, adjusted to the forward start period.

Plain Vanilla Swap example.



Forward Start Swap Example.



To obtain the present value of a period, the future flow must be quantified and discounted at present value. That is, the following must be defined:

2. Compounding

The compounding method for floating legs, can be run into two different methods that are described as follows:

- *Flat Compounding*:

In a floating leg with Flat Compounding, the notional amount plus accrued interest arising from the previous floating rate is applied to the present floating interest rate. The spread, however, applies only in the notional amount. The accrued amounts are added up on the payment date.

$$NPV_{cfV} = \sum_{w=1}^{m} \left(RV_{cfw} * P(VD, PD_w) \right)$$

$$RV_{\mathrm{cfw}} = \sum_{j=1}^{sp} \left(AI_{cfj} \right)$$

$$AI_{cfj} = N * \left(f_j + s\right) * \delta\left(SD_j, ED_j\right) + f_j * \delta\left(SD_j, ED_j\right) * \sum_{k=1}^{j-1} AI_{cfk}$$

Where:

- *sp:* the number of sub-periods (e.g. 4 quarterly) in the period w (e.g.: 1 year up to 50 years).
- AI_{cfj}: *The accrued interest for a period w or the sub-period j of a swap.*

- *Straight Compounding*:

In a floating leg with Straight Compounding, both the floating interest rate and the spread are applied to the notional amount plus accrued interest arising from the previous floating rate is applied to the present floating interest rate. The accrued amounts are added up on the payment date.

$$NPV_{csV} = \sum_{w=1}^{m} \left(RV_{csw} * P(VD, PD_w) \right)$$

$$RV_{\mathrm{csw}} = \sum_{j=1}^{sp} \left(AI_{csj} \right)$$

$$AI_{csj} = N * \left(f_j + s\right) * \delta\left(SD_j, ED_j\right) + \left(f_j + s\right) * \delta\left(SD_j, ED_j\right) * \sum_{k=1}^{j-1} AI_{csk}$$

Where:

- *sp:* the number of sub-periods (e.g. 4 quarterly) in the period w (e.g.: 1 year up to 50 years).
- AI_{csj}: The accrued interest for a period w or the sub-period j of a swap.
- N: The notional amount of transaction.
- f_j: Implied floating forward rate applied in period between dates t_j and t_{j+1}, for j = 0… m, where m is the maturity date of the transaction or termination date.
- s: The spread applied to the implied forward rate, with either its positive or negative sign.
- $\delta(SD_j, ED_j)$: Fraction of year of floating leg, for period between the Period Start Date and the Period End Date, based on ACT/360 convention.
- $P(VD, PD_w)$: Discount factor for the floating leg corresponding to period between valuation Date and Payment Date for period w "PD_w"

3. Valuation of Plain Vanilla Swaps

The NPV of a Plain Vanilla Swap is calculated as the difference from the NPV of each leg, where these are calculated with the following formulas:

- Fixed leg:

$$\boldsymbol{NPV_f = \sum_{i=1}^{n} (N_i * R * \delta(SD_i, ED_i) * P(VD, PD_i))}$$

- Floating leg:

$$\boldsymbol{NPV_v = \sum_{j=1}^{m} \left(N_j * (f_j + s) * \delta(SD_j, ED_j) * P(VD, PD_j)\right)}$$

Where:

- NPV_f: Present Value of Fixed Leg
- NPV_v Present Value of Floating Leg
- $N_{i\ o\ j}$: The notional amount of transaction for period i o j.
- R: Fixed rate to apply to fixed leg.

- f_j: Implied floating forward rate applied in period between dates t_j and t_{j+1}, for j = 0… m, where m is the maturity date of the transaction or termination date.
- s: The spread applied to the implied forward rate, with either its positive or negative sign.
- $\delta(\mathrm{SD}_i, \mathrm{ED}_i)$: Year fraction of fixed leg, for period between the period start date and the period end date i, based on 30/360 convention.
- $\delta(\mathrm{SD}_j, \mathrm{ED}_j)$: Year fraction of floating leg, for period between the period start date and the period end date j, based on ACT/360 convention.
- $P(VD, PD_i)$: Discount factor of fixed leg corresponding to period between Valuation Date and payment date for period i "PD_i".
- $P(VD, PD_j)$: Discount factor of floating leg corresponding to period between Valuation Date and payment date for period i "PD_j".

4. Valuation of Basis Swaps

The NPV of a Basis Swap is calculated as the difference from the NPV of each leg, where these are calculated with the following formulas:

- Floating leg 1:

$$\boldsymbol{NPV_{v1}} = \sum_{\boldsymbol{j=1}}^{\boldsymbol{n}} (\boldsymbol{N_i} * (\boldsymbol{f_i} + \boldsymbol{s}) * \boldsymbol{\delta}(\boldsymbol{SD_j}, \boldsymbol{ED_j}) * \boldsymbol{P}(\boldsymbol{VD}, \boldsymbol{PD_i}))$$

- Floating leg 2:

$$\boldsymbol{NPV_{v2}} = \sum_{\boldsymbol{j=1}}^{\boldsymbol{m}} (\boldsymbol{N_j} * \boldsymbol{f_j} * \boldsymbol{\delta}(\boldsymbol{SD_j}, \boldsymbol{ED_j}) * \boldsymbol{P}(\boldsymbol{VD}, \boldsymbol{PD_j}))$$

Where:

- NPV_{v1}: Present Value of Floating Leg 1.
- NPV_{v2}: Present Value of Floating Leg 2.
- $N_{i\ o\ j}$: The notional amount of transaction for period i o j.
- f_i: Implied floating forward rate applied in period between dates t_i and t_{i+1}, for j = 0… n, where n is the maturity date of the transaction or termination date on floating leg 1.

- f_j: Implied floating forward rate applied in period between dates t_j and t_{j+1}, for j = 0… m, where m is the maturity date of the transaction or termination date on floating leg 2.

- s: The spread applied to the implied forward rate, with either its positive or negative sign.

- $\delta(\mathrm{SD}_i, \mathrm{ED}_i)$: Year fraction of floating leg 1, for period between the period start date and the period end date i, based on ACT/360 convention.

- $\delta(\mathrm{SD}_j, \mathrm{ED}_j)$: Year fraction of floating leg 2, for period between the period start date and the period end date j, based on ACT/360 convention.

- $P(VD, PD_i)$: Discount factor of floating leg 1 corresponding to period between Valuation Date and payment date for period i "PD_i".

- $P(VD, PD_j)$: Discount factor of floating leg 2 corresponding to period between Valuation Date and payment date for period j "PD_j".

That is, both legs are indexed to floating rates. The floating rate f_j may be associated to a different floating reference rate (3M Euribor against 6M Euribor, or EuroSTR against one of the Euribor Index)) or the same (3M Euribor), but settled with a different frequency. The reset frequency must be associated with the term specific of the floating rate index tenor. For example, leg 1 settled annual and leg 2 settled quarterly, although both are indexed to the 3M Euribor. The reset frequency will be quarterly as references in both legs are 3M Euribor.

It is irrelevant if the spread is added to on floating leg 1 or 2, as both legs pay floating flows.

5. Valuation of zero coupon swaps

The NPV of a zero coupon swap is calculated as the difference from the NPV of each leg, where either one or both are settled at maturity in a single flow and with no periodic frequency. These NPVs are calculated with the following formulas:

- Zero Coupon Fixed leg:

$$\boldsymbol{NPV_{zcF} = N * R * \delta(SD, t_{end}) * P(VD, t_{end})}$$

Where

- N: The notional amount.

- R: Fixed rate to be applied to the fixed leg.

- $\delta(SD_i, T_{end})$: Year fraction of fixed leg, for period i between the period start date and maturity date "t_{end}", based on the correspondent basis convention.
- $P(VD, t_{end})$: Discount factor of fixed leg corresponding to period between Valuation Date and maturity date "t_{end}".

- Zero Coupon Floating leg:

$$\boldsymbol{NPV_{zcV}} = \left(\sum_{j=1}^{sp} \boldsymbol{AI_{zcVj}}\right) * \boldsymbol{P(VD, t_{end})}$$

$$\boldsymbol{AI_{zcVj}} = \boldsymbol{N} * (\boldsymbol{f_j} + \boldsymbol{s}) * \boldsymbol{\delta}(\boldsymbol{SD_j}, \boldsymbol{ED_j}) + \left(\sum_{l=1}^{j-1} \boldsymbol{AI_{zcVl}}\right) * (\boldsymbol{f_j} + \boldsymbol{s}) * \boldsymbol{\delta}(\boldsymbol{SD_j}, \boldsymbol{ED_j})$$

Where:

- AI_{zcVj}: Accrued Interest for a period j of the floating leg of a Zero Coupon Swap.
- sp: Number of sub-period (i.e.: 4 quarterly) for the period j (i.e.: From 1 to 50 years).
- N: The notional amount of transaction.
- f_j: Floating forward rate with the reset frequency of the floating index (Monthly, Quarterly, etc.....) applied in period between dates t_j and t_{j+1}, for j = 0… m-1, where m is the maturity date of the transaction or termination date.
- s: The spread applied to the implied forward rate, with its positive or negative sign.
- $\delta(SD_j, ED_j)$: Year fraction of floating leg, for period between the period start date and period end date based on the correspondent basis convention.
- $P(VD, t_{end})$: Discount factor of fixed leg corresponding to period between valuation date and maturity date "t_{end}".

The compounding method in a floating leg could be straight or flat.

The formulas in this section deal with the case where both legs of a Zero Coupon Swap are zero rate, but it may be the case that only one of them is zero rate. In this situation, the valuation criteria set out above in Plain Vanilla Swap would apply to the non-zero rate leg.

6. Valuation of Overnight Index Swaps (OIS)

Valuation of an OIS is similar to that of a Plain Vanilla Swap, where the NPV is the difference from the NPV of each of the legs. The difference is that the floating leg is settled against the EuroSTR rate, and not the Euribor. Both NPVs are calculated with the following formulas:

- Fixed leg:

$$NPV_f = N * \sum_{i=1}^{n} (R * \delta(SD_i, ED_i) * P(VD, PD_i))$$

Where:

  - NPV_f: Present Value of Fixed Leg
  - N: The notional amount of transaction.
  - R: Fixed rate to apply to fixed leg.
  - $\delta(SD_i, ED_i)$: Year fraction of fixed leg, for period between the initial payment date and the end payment date, based on ACT/360 convention.
  - $P(VD, PD_i)$: Discount factor of fixed leg corresponding to period between valuation date and payment date for period i (PD_i).

- Floating leg:

$$Floating\ Rate_i = \left(\prod_{j=1}^{D} (1 + ONr_j * \delta(j, j+1)) - 1 \right) * \frac{360}{D}$$

$$NPV_v = N * \sum_{i=1}^{n} (Tipo\ Variable_i * \delta(SD_i, ED_i) * P(VD, PD_i))$$

Where:

  - $Floating\ Rate_i$: Floating rate to be applied to the floating rate for the period i.
  - D: Number of days for calculation period i.
  - ONr_j: Overnight rate fixed or implied rate on date j.
  - $\delta(SD_i, ED_i)$: Year fraction of floating leg 1, for period between the period start date and the period end date i, based on ACT/360 convention.
  - NPV_v: Present Value of Floating Leg.

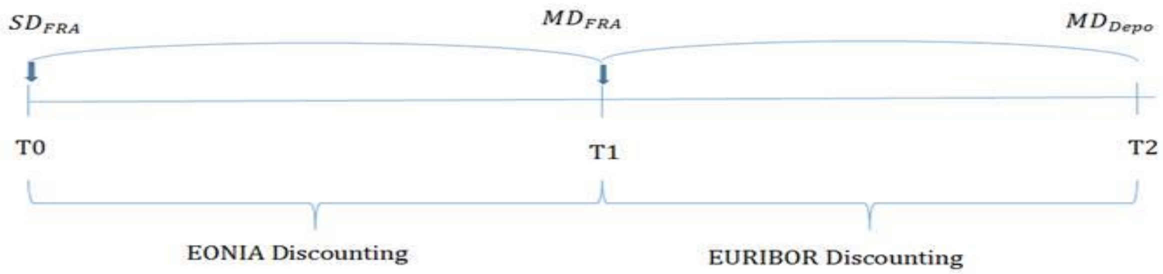
- N: The notional amount of transaction.

- $\delta(j, j+1)$: Year fraction for period between the period start date and the next date, based on ACT/360 convention.

- $P(VD, PD_i)$: Discount factor of fixed leg corresponding to period between valuation date and payment date for period i PD_i.

7. FORWARD RATE AGREEMENT (FRA)

The NPV of a FRA is the present value, on t_0, of the difference between the agreed FRA rate and the floating reference rate settled on the FRA's maturity date, on t_1. Graphically, the valuation of an FRA would be as follows:



And the formula for calculation of the present value of the FRA:

$$\boldsymbol{NPV = N * \left(f_j - R(MD_{FRA}, MD_{Depo})\right) * \delta(MD_{FRA}, MD_{DEPO}) * P(MD_{FRA}, MD_{Depo}) * P(VD, MD_{FRA})}$$

Where:

- $\mathrm{R}(\mathrm{MD}_{\mathrm{FRA}}, \mathrm{MD}_{\mathrm{Depo}})$: The agreed forward rate from the FRA's settlement date MD_{FRA} to the date MD_{Depo}.

- f_j: Floating implied rate applied in the period between the dates MD_{FRA} and MD_{Depo}. It is obtained from the corresponding zero rate curve via linear interpolation of the Zero Rates.

- MD_{FRA}: The maturity and settlement date of the FRA.

- MD_{Depo}: The maturity and settlement date of the notional underlying deposit.

- SD_{FRA}: The trade date of the FRA.

- $P(MD_{FRA}, MD_{Depo})$: It is the discount factor between the maturity date of the notional underlying deposit and the maturity and settlement date of the FRA, at the corresponding Euribor rate.

- $P(VD, MD_{FRA})$: It is the discount factor between the Valuation date and the maturity and settlement date of the FRA, at the EuroSTR rate.

Calculation of the NPV of an FRA in the period between t_1 and t_2 will discount at the corresponding Euribor rate at settlement date (t_1), while calculation of the NPV of the FRA today (on t_0) will discount at the OIS curve.

If the difference $\left(f_j - R\left(MD_{FRA}, MD_{Depo}\right)\right)$ is higher than 0 on the FRA's settlement date, this would result in a gain for the buyer of the FRA. If the difference $\left(f - R\left(MD_{FRA}, MD_{Depo}\right)\right)$ is lower than 0, this would result in a loss for the buyer of the FRA.

8. Valuation of Considerations

For all kind of trades described in this circular it may be necessary to add the value of the considerations.

The valuation of the considerations, with its respective sign positive or negative, will be made by discounting the amount of the considerations with the corresponding discount factor for the date the flow is taken into account.

$$\mathbf{NPV}_{\boldsymbol{Consideration}} = {}^{+}/_{-}\,\mathbf{Consideration} * \mathbf{P}(\mathbf{VD}, \mathbf{CD})$$

Where:

- $\mathrm{NPV}_{Consideration}$: Is the Net Present Value of the consideration.
- ${}^{+}/_{-}\,\mathrm{Consideration}$: Is the gross amount of the consideration taking into account its sign, this means, if the consideration is paid or received.
- $\mathrm{P}(\mathrm{VD}, \mathrm{CD})$: Is the Discount Factor for the period between Valuation Date and the Payment date for the consideration.

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