FIXED INCOME RISK ENGINE

Mark-to-Market Margins

Methodological notes

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1 Introduction

This document describes the methodology for computing the *Mark-to-market Margin* for the Clearing Members with outstanding positions at the evaluation date on the *Fixed Income* Section.

In particular, all positions are assigned to the *cash*, *repo* and *forward starting repo* categories according to their particular contractual features. Each of the aforementioned categories implies the adoption of a different calculation methodology of the *Mark-to-market Margin*, in order to take into due consideration the specific riskiness associated with it.

In order to allocate the contracts in the *cash*, *repo* and *forward starting repo* categories, the following should be kept in mind:

1. *cash* positions consist of all *spot* bond purchase contracts whose settlement has still to take place (usually these positions settle in *two* business days after the *trade date*);

2. *repo* positions consist of all *spot vs term* trades (*repurchase agreements*) whose *spot leg* has already settled and *term leg* has yet to settle;

3. *forward starting repo* positions consist of all *repos* whose *spot leg* and *term leg* have both yet to settle.

The calculation methodology of the *Mark-to-market Margin* applies to all types of securities subject to margining.

The following sections describe in detail the calculation methodologies of the *Mark-to-market Margin* for each of the categories described above.

2 *Mark-to-Market Margin – Cash* positions

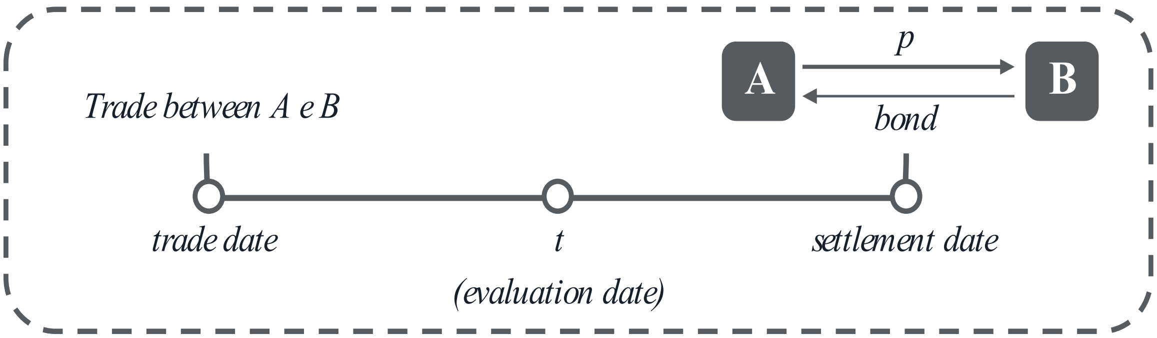
Below described is how to close a hypothetical bond *cash* trade in the event of the default of one of the two counterparties of the contract.

2.1 Close out of *cash* positions after *bond buyer*'s default

Consider the following *cash* trade: at *trade date* A and B sign a contract whereby A (*long* position) will buy from B (*short* position) a bond at price *p*. The settlement of the contract will occur at *settlement date*.

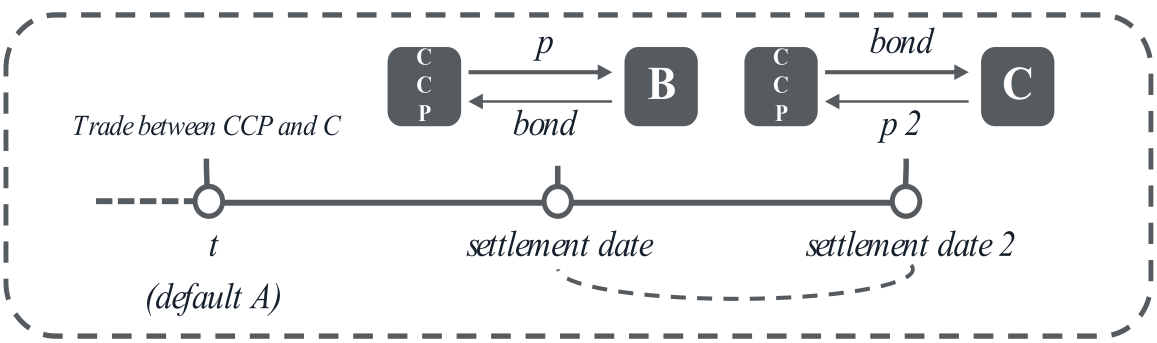
The trade can be portrayed as follows (*trade date* < *t* < *settlement date*):

Figure 2-1*: Cash* trade



Assuming that in *t*, i.e. at evaluation date, the default of A (*long* position) occurs, the operations that the CCP must carry out in order to ensure the regular close out of the original position are represented in the following figure:

Figure 2-2: Close out of *cash* position (default of A – *long* position)



In order to close the original position, in *t* the CCP must sell *spot* the bond on the market (to C) at price *p2* (operation that will settle at *settlement date 2*), with the aim of carrying out an operation of opposite sign compared to the original operation here being closed. At *settlement date* the CCP then substitutes A in the settlement of the original contract, paying the amount *p* and collecting the *bond*. At *settlement date 2* the CCP instead collects *p2* and transfers the *bond* to C, with whom it had stipulated the *cash* contract in *t* (that is, at default date of A).

The overall effect of the close out operation described above, net of the cash advance to which the CCP is subject at *settlement date* due to the misalignment of the settlement dates of the two contracts (the original one and that signed for close out purposes), consists of the difference between *p* and *p2*, i.e. the settlement price of the bond in the original trade and the settlement price of the bond considering the trade between the CCP and C in *t*.

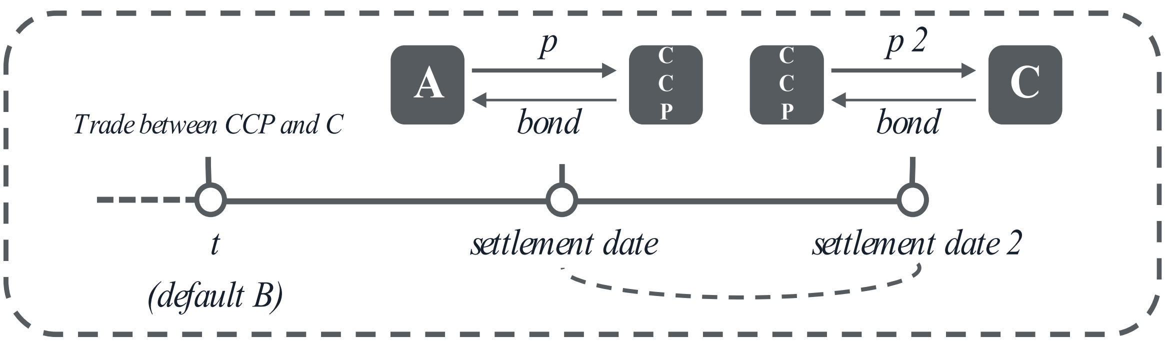
In this case, for A the *Mark-to-market Margin* will be:

- a credit if $p2 > p$;
- a debt if $p2 < p$.

2.2 Close out of *cash* positions after *bond seller*'s default

Similarly to what outlined in the previous paragraph, always referring to the trade depicted in Figure 2-1, assume now that in *t*, i.e. at evaluation date, the default of B (*short* position) occurs. The operations that the CCP must carry out in order to ensure the regular close out of the original position are represented in the following figure:

Figure 2-3: Close out *cash* position (default of B – *short* position)



In this case, in order to close the original position, in *t* the CCP must buy *cash* the bond on the market (from C) at price *p2* (operation that will settle at *settlement date* 2), with the aim of carrying out an operation of opposite sign compared to the original operation here being closed. At *settlement date* the CCP collects the amount *p*. Since the trade between the CCP and C settles after the *settlement date* of the original contract, A will have the *bond* transferred at *settlement date 2* (in this case, the time lag, which in case of default of A resulted in a cash advance by the CCP, instead results in A collecting the *bond* at *settlement date 2* instead of *settlement date*). Therefore, at *settlement date 2* the CCP pays *p2* and collects the *bond* from C, with whom it had stipulated the *cash* contract in *t* (that is, at default date of B). The CCP then transfers the *bond* to A.

The overall effect of the close out operation described above, net of the delay in the delivery of the bond to which A is subject due to the misalignment of the settlement dates of the two contracts (the original one and that signed for close out purposes), consists of the difference between *p* and *p2*, i.e. the settlement price of the bond in the original trade and the settlement price of the bond considering the trade between the CCP and C in *t*.

In this case, for B the *Mark -to-market Margin* will be:

- a credit if $p2 < p$;
- a debt if $p2 > p$.

2.3 Calculating M*ark-to-market Margin* for *cash* positions

In light of what outlined in the previous paragraphs, the *Mark-to-market Margin* of a *cash* position is a function of the following components:

1) market price of the traded bond at evaluation date;
2) original settlement price of the bond;
3) accrued interest of the bond at original settlement date;
4) principal of the position in bond;
5) position sign (+ : *long* / - : *short*).

The *Mark-to-market Margin* calculation formula is:

(1) $MtM_{margin} = N * \left(\frac{P_{market} + AI_{SD}}{100} - \frac{P_{trade} + AI_{SD}}{100}\right) * ps$,

with N: principal; P_{market}: market price at evaluation date (i.e. *p2*); P_{trade}: original settlement price (i.e. *p*); AI_{SD}: contractual accrued interest;[1] ps: position sign (+ : *long* / - : *short*).

In particular, $\frac{P_{trade} + AI_{SD}}{100} * N$ is the contractual traded amount; in the original contract it is also available the principal of the position N. P_{market} is directly available from the market, while AI_{SD} is computed by employing the last coupon date, the *settlement date* and the next coupon date, as in the following example:

***AI_{SD}* calculation example**:

- ISIN: IT0004992308
- Coupon rate: 2,5% (annualized)
- Coupon frequency: semiannual
- Principal: 100

[1] The accrued interest is computed for *cash* positions at *settlement date* and not at evaluation date since the difference between the two is considered negligible (*cash* positions usually settle 2 days after the trade date).

- Last coupon date: 01/05/2018
- Next coupon date: 01/11/2018
- *Settlement date*: 04/05/2018

$$AI_{SD} = \frac{0{,}025*100}{2} * \frac{(20180504\text{-}20180501)}{(20181101\text{-}20180501)} = 0{,}02038.$$

3 *Mark-to-Market Margin – Repo* positions

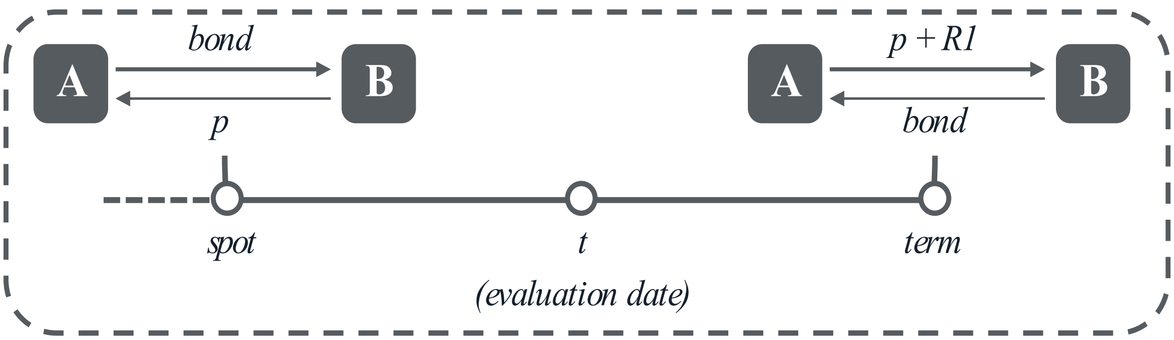
Below described is how to close a hypothetical bond *repo* trade in the event of the default of one of the two counterparties of the contract.

3.1 Close out of *repo* positions after *cash borrower*'s default

Consider the following *repo* trade: at *trade date* A and B sign a contract whereby at *spot date* A (*long* position) delivers to B (*short* position) the *bond* for a cash amount equal to *p*. At *term date*, B returns to A the *bond* in exchange for a cash amount equal to *p*+*R1*, pre-defined at *trade date* (with *R1*: *repo interest*, function of *repo rate,* contract maturity and nominal amount of the trade).

The trade can be portrayed as follows (*spot date* < *t* < *term date*; *repo* trades here described have *spot leg* already settled and *term leg* yet to settle):

Figure 3-1: R*epo* trade

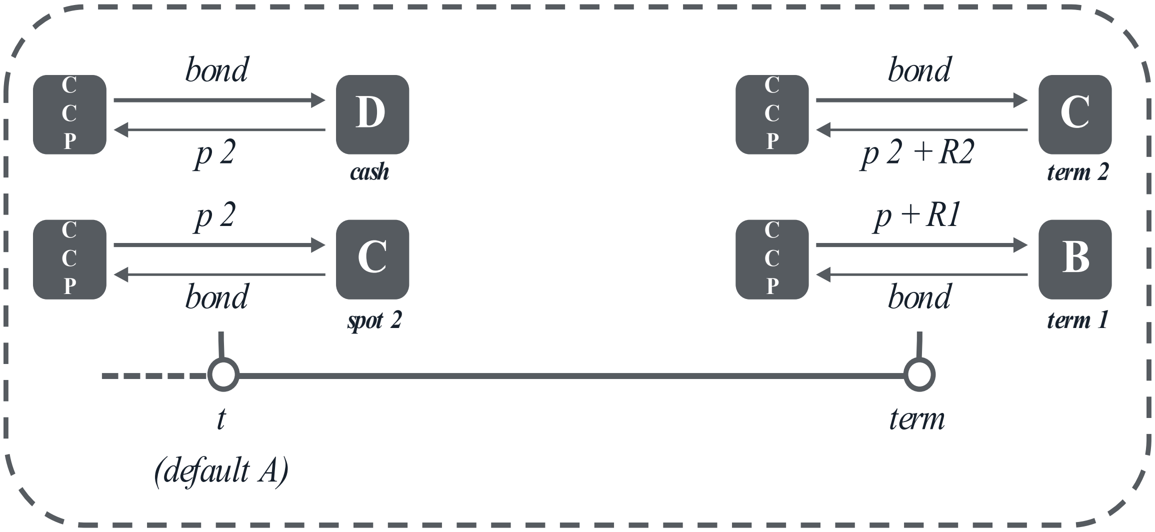


Assuming the *cash borrower* (*long* position) defaults in *t*, the CCP in *t* must:

1) enter into a *reverse repo* on the bond with C, with maturity equal to *term date–t* (with *term date*: *settlement date* of the *term leg* of the *original repo trade* between A and B). The *repo trade* with C will have a *repo rate R2* and with a price *p2* of the underlying security different from that of the *original repo trade*;
2) sell *spot* to D the *bond* at price *p2*.

The operations outlined above, together with the *term leg* of the *original repo trade*, allow the CCP to close the position exposed to the default of A:

Figure 3-2: Close out of *repo* position (default of A – *long* position, *cash borrower*)



The overall effect of the close out operations in Figure 3-2 carried out by the CCP can be depicted in tabular form as follows:

Table 1: Close out *repo* position (default of A – *long* position, *cash borrower*)

	t	*Term date*
Repo trade with C	- *p 2*	
Repo trade with C	+ *bond*	
Repo trade with C		- *bond*
Repo trade with C		+ *p 2* + R2
Cash trade with D	- *bond*	
Cash trade with D	+ *p 2*	
Original repo trade		- *p* - R1
Original repo trade		+ *bond*

Table 1 shows that, besides the difference in prices *p* and *p2* (similar to those faced in closing out *cash* positions), the overall effect of the close out operations is equal to the difference between *R2* and *R1* (i.e. *repo interest* of the *repo trade* with C and *repo interest* of the *original repo trade*).

In particular, as far as the *repo interest* component is concerned, for A the *Mark -to-market Margin* will be:

- a credit if *R2* > *R1*;
- a debt if *R2* < *R1*.

As far as the difference between *p* and *p2* is concerned, what outlined at the end of paragraph 2.1 still applies.

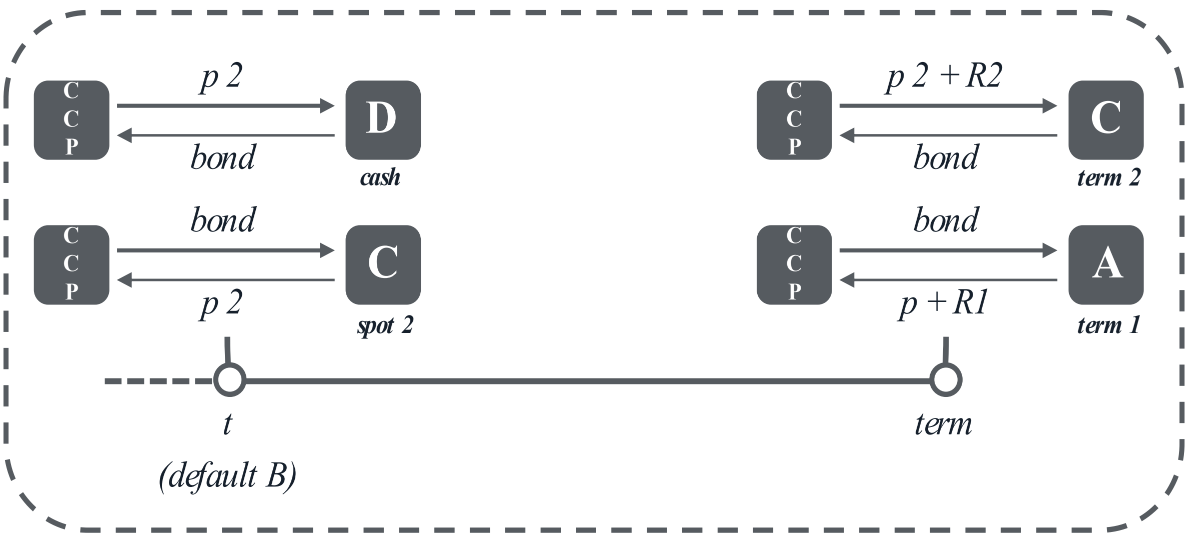
3.2 Close out *repo* positions after *cash lender*'s default

Similarly to what outlined in the previous paragraph, always referring to the trade depicted in Figure 3-1, assume now the *cash lender* (*short* position) defaults in *t*, the CCP in *t* must:

1) enter into a *repo* on the bond with C, with maturity equal to *term date–t* (with *term date*: *settlement date* of the *term leg* of the *original repo trade* between A and B). The *repo trade* with C will have a *repo rate R2* and a price *p2* different from those of the *original repo trade*;
2) buy *spot* from D the *bond* at price *p2*.

The operations outlined above, together with the *term leg* of the *original repo trade*, allow the CCP to close the position exposed to the default of B:

Figure 3-3: Close out *repo* position (default of B – *short* position, *cash lender*)



The overall effect of the close out operations in Figure 3-3 carried out by the CCP can be depicted in tabular form as follows:

Tabella 2: Close out of *repo* position (default of B – *short* position, *cash lender*)

	t	*Term date*
Repo trade with C	+ *p 2*	
Repo trade with C	- *bond*	
Repo trade with C		+ *bond*
Repo trade with C		- *p 2* - R2
Cash trade with D	+ *bond*	
Cash trade with D	- *p 2*	
Original repo trade		+ *p* + R1
Original repo trade		- *bond*

Table 1 shows that, besides the difference in prices *p* and *p2* (similar to those faced in closing out *cash* positions), the overall effect of the close out operations is equal to the difference between *R2* and *R1* (i.e. *repo interest* of the *repo trade* with C and *repo interest* of the *original repo trade*).

In particular, as far as the *repo interest* component is concerned, for B the *Mark -to-market Margin* will be:

- a credit if *R2* < *R1*;
- a debt if *R2* > *R1*.

As far as the difference between *p* and *p2* is concerned, what outlined at the end of paragraph 2.1 still applies.

3.3 Calculating *repo interest spread*

In order to compute the *Mark-to-market Margin* for *repo* positions, besides the difference in bond prices *p* (*trade date*) and *p2* (evaluation date), it is thus necessary to estimate the *repo rate* of the *closing repo trade* in *t* (evaluation date). After having estimated this quantity, one can compute the corresponding *repo interest R2* and finally the *Mark-to-market Margin*.

The steps in the estimation of the *repo rate* of the *closing repo trade* carried out by the CCP in *t* are the following:

a) retrieve the *OIS/EONIA spot curve*[2] at *trade date*;
b) compute the duration of the *original repo trade*;
c) find on the *OIS/EONIA spot curve* the *tenor* corresponding to the duration of the *original repo trade*;
d) find the *rate* corresponding to the *tenor* on the *OIS/EONIA spot curve* corresponding to the duration of the *original repo trade*;
e) compute the *original OIS spread* as the difference between the *original repo rate* (hereinafter also *repo rate 1*) and the *OIS rate* corresponding to the *tenor* on the *OIS/EONIA spot curve* corresponding to the duration of the *original repo trade*;
f) retrieve the *OIS/EONIA spot curve* at evaluation date *t*;
g) compute the duration of the *closing repo trade*;
h) find on the *OIS/EONIA spot curve* the *tenor* corresponding to the duration of the *closing repo trade*;
i) find the *rate* corresponding to the *tenor* on the *OIS/EONIA spot curve* corresponding to the duration of the *closing repo trade*;

[2] Bootstrapped from *EONIA par swap rates*.

j) compute the *closing repo rate* (hereinafter also *repo rate 2*) as sum of the *OIS rate* corresponding to the *tenor* on the *OIS/EONIA spot curve* corresponding to the duration of the *closing repo trade* and the *original OIS spread*.

The *repo rate* of the post-default *closing repo trade* is thus calculated by adding the *spread* of the *original repo rate* with respect to the *trade date* risk-free *OIS/EONIA spot curve* on top of the evaluation date *t OIS/EONIA spot curve*, taking into account the different duration of the *closing repo trade* with respect to that of the *original* one (i.e. the reference *tenor* will be different as *t > trade date*)[3].

Once *repo rate 2* has been computed, it is possible to compute *R1* and *R2* as follows:

$$(2)\ R1 = \frac{(\text{term\_date - spot\_date})_{\text{days}} * \frac{P_{\text{trade}} + AI_{\text{SSD}}}{100} * N * \text{repo\_rate\_1}}{36000};$$

$$(3)\ R2 = \frac{(\text{term\_date - t})_{\text{days}} * \frac{P_{\text{market}} + AI_{\text{E1D}}{}^{4}}{100} * N * \text{repo\_rate\_2}}{36000};$$

with *repo rate 1* and *repo rate 2*: *original* and *closing repo rates* computed following above steps a)-j).

Repo interest spread calculation example

Assume the contractual traded *spot* amount $(P_{\text{trade}} + AI_{\text{SSD}}) * \frac{N}{100}$ can be extracted directly from the contract and equal to 9.213.910,20 €. Assume also the contractual traded *term* amount is available and equal to 9.212.387,35 €. *R1* can be directly computed as difference between contractual traded *term* and *spot* amounts (9.212.387,35 – 9.213.910,20 = -1.522,85 € – corresponding to a *repo rate 1*, by inverting formula (2), equal to -0,4250). However, calculating the *original repo rate* is necessary, even though *R1* can be directly computed given the contractual traded amounts, in order to compute the *original OIS spread* according to above step e).

Given $(\text{term\_date - spot\_date})_{\text{days}}$ equal to 14 days (16/05/2018 – 02/05/2018) and evaluation date 04/05/2018, and assuming the following term structure of the *OIS/EONIA spot curve* at *trade date* (27/04/2018):

[3] In case the (*original/closing*) *repo trade* maturity doesn't match any particular tenor of the *OIS/EONIA spot curve*, it is necessary to linearly interpolate rates in order to obtain the proper *OIS rate*.

[4] AI_{SSD} represents the accrued interest at *spot leg settlement date* while AI_{E1D} represents the accrued interest at evaluation date + 1 business day.

	O/N (1 day)	1W (7 days)	2W (14 days)
27/04/2018	-0,365	-0,338	-0,3634

The *rate* computed according to above step d) is equal to -0,3634. The *original OIS spread* is therefore equal to -0,4250 + 0,3634 = -0,0616.

Assume now the following term structure of the *OIS/EONIA spot curve* at evaluation date (04/05/2018):

	O/N (1 day)	1W (7 days)	2W (14 days)
04/05/2018	-0,368	-0,3628	-0,3623

The maturity of the hypothetical *closing repo trade* is equal to $(\text{term\_date - t})_{\text{days}}$ = 12 days (16/05/2018 – 04/05/2018). Therefore, the *rate* computed according to above step i) is equal to -0,3628 + (-0,3623 + 0,3628) * (12 – 7) / (14 – 7) = -0,3624 (i.e. obtained by linearly interpolating from 7 day- and 14 day-*rates*, as the *closing repo trade* maturity – 12 days – doesn't match any particular tenor of the *OIS/EONIA spot curve*).

The *repo rate 2* computed according to above step j) is thus equal to -0,3624 – 0,0616 = -0,4240.

Being P_{market} available from the market, one has lastly to compute AI_{E1D}, following what outlined in paragraph 2.3 and by employing evaluation date + 1 business day (in this example 07/05/2018).

3.4 Calculating *Mark-to-market Margin* for *repo* positions

Once *R1* e *R2* have been computed, it is possible to compute the M*ark-to-market Margin*. However, one has to bear in mind that both the differences in prices and repo rates are effective at *settlement date* of the *original repo trade term leg*: discounting (as *t* ≤ *term date*) the respective amounts is therefore necessary.[5]

(4) $MtM_{margin} = (N * \left(\frac{P_{market} + AI_{E1D}}{100} - \frac{P_{trade} + AI_{SSD}}{100}\right) - (R1 - R2)) * OIS_{discount\_factor} * ps,$

with $OIS_{discount\_factor}$: *OIS/EONIA discount factor* from *term date* to evaluation date *t*, computed according to the following steps:

a) compute *term date – t* in year fractions;
b) linearly interpolate from *OIS rates* at evaluation date *t* to obtain the *OIS rate* corresponding to *tenor term date - t*;

[5] The same should apply to *cash* positions, however in that case the time lag between evaluation date and *settlement date* is always negligible.

c) turn the obtained *OIS rate* into the *OIS discount factor* by employing the following formula: $OIS_{discount\_factor} = \frac{1}{(1+OIS\_rate/100)^{\frac{(term\_date-t)}{365}}}$.

OIS/EONIA discount factor calculation example:

Consider the previous example, where $(term\_date - t)_{days}$ = 12 days (16/05/2018 – 04/05/2018). The *OIS rate* is equal to -0,3624 (obtained by linearly interpolating as described above). The *OIS discount factor* will thus be equal to:

$$\frac{1}{(1-0{,}003624)^{\frac{12}{365}}} = 1{,}000119.$$

4 *Mark-to-Market Margin - Forward starting repo* positions

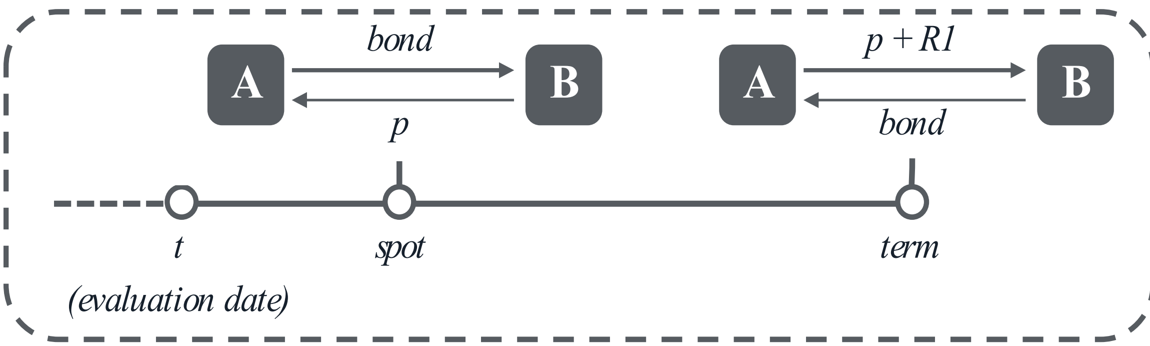
Below described is how to close a hypothetical bond *forward starting repo* trade in the event of the default of one of the two counterparties of the contract.

4.1 Close out of *forward starting repo* positions

Consider the following *repo* trade: at *trade date* A and B sign a contract whereby at *spot date* A (*long* position) delivers to B (*short* position) the *bond* for a cash amount equal to *p*. At *term date*, B returns to A the *bond* in exchange for a cash amount equal to *p*+*R1*, pre-defined at *trade date* (with *R1*: *repo interest*, function of *repo rate* and contract maturity).

The trade can be portrayed as follows (*t* < *spot date* < *term date*; *forward starting repo* trades subject to margining have both *spot leg* and *term leg* yet to settle):

Figure 4-1: *Forward starting repo* trade



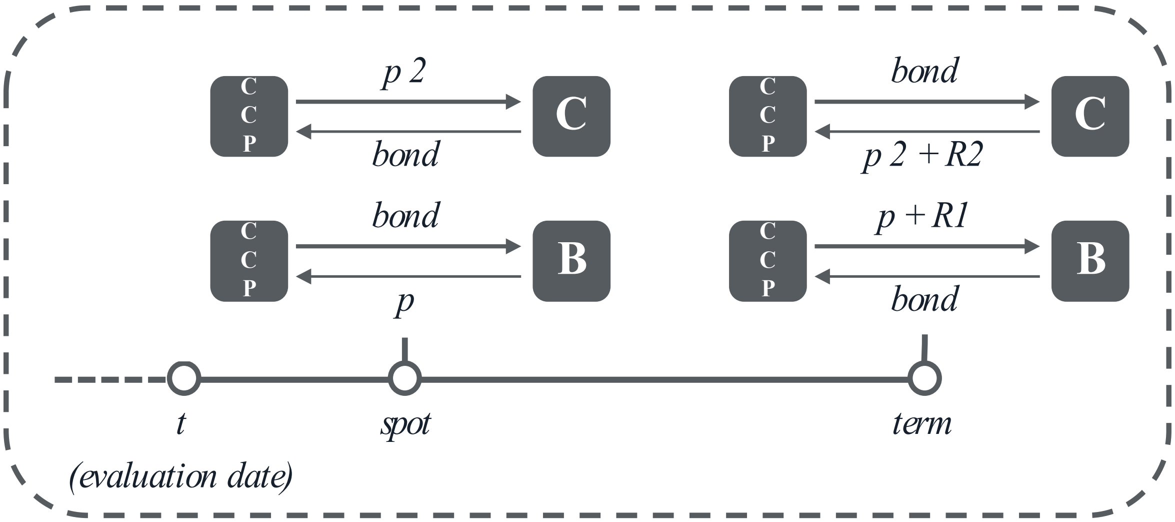
Unlike what outlined in chapter 3, the CCP has not to set up *spot* operations on the market. The only close out operation indeed consists in entering into a *repo* on the bond of opposite sign and with the same *legs' settlement dates* with respect to the original one.

Assuming the *cash borrower* (*long* position) defaults in *t*, the CCP in *t* must:

1) enter into a *reverse repo* on the bond with C, with maturity equal to *term date–spot date* (with *term* and *spot dates*: *settlement dates* of the *term* and *spot legs* of the *original repo trade* between A and B, respectively). The *repo trade* with C will have a *repo rate R2* and a price *p2* different from those of the *original repo trade.*

The operation outlined above, together with the *legs* of the *original repo trade*, allow the CCP to close out the position exposed to the default of A:

Figure 4-2: Close out of *forward starting repo* position (default of A – *long* position, *cash borrower*)



The overall effect of the close out operation in Figure 3-2 carried out by the CCP can be depicted in tabular form as follows:

Table 3: Close out of *forward starting repo* position (default of A – *long* position, *cash borrower*)

	Spot date	***Term date***
Repo trade with C	- *p 2*	
Repo trade with C	+ *bond*	
Repo trade with C		- *bond*
Repo trade with C		+ *p 2* + R2
Original repo trade	- *bond*	
Original repo trade	+ *p*	
Original repo trade		- *p* – R1
Original repo trade		+ *bond*

As far as the difference in prices *p* and *p2* is concerned, it is due to the fact that the *trade dates* are different. However, unlike what outlined in chapter 3, there is no simultaneous close out of the positions of opposite signs. Although *p2* is paid and collected by the CCP, these two operations indeed occur at *spot date* and *term date*, respectively. Therefore, the impact of the difference between *p* and *p2* is proportional to the difference between the two discount factors (from *term date* to evaluation date *t* and from *spot date* to *t*, respectively).

As far as the *repo interest* component is concerned, the difference between *R2* and *R1* (computed as outlined in paragraph 3.3 – with the difference that both *repo interests* are computed on the same time interval *term date* – *spot date,* as the two *repo trades* have the same maturity) is instead entirely settled at *settlement date* of the *term leg*, thus having the same impact as captured by formula (4).

For A the *Mark -to-market Margin* will be:

- a credit if *discounted p2 > discounted p, R2 > R1*;
- a debt if *discounted p2 < discounted p, R2 < R1*.

In case of *default* in *t* of the *cash lender* (*short* position - B) the same logic applies, of course inverting all signs.

4.2 Calculating *Mark-to-market Margin* for *forward starting repo* positions

In light of what outlined in the previous sections, the *Mark-to-market Margin* for *forward starting repo* positions is computed as follows[6]:

$$(5)\ MtM_{margin} = ((N^*\left(\frac{P_{market}+AI_{SSD}}{100}-\frac{P_{trade}+AI_{SSD}}{100}\right))^*(OIS_{df2}-OIS_{df1})-(R1-R2)^*OIS_{df2})^*ps\ ,$$

with OIS_{df1} and OIS_{df2} computed according to the following steps:

a) compute *term date – t* in year fractions;
b) linearly interpolate from *OIS rates* at evaluation date *t* to obtain the *OIS rate 2* corresponding to *tenor term date - t*;
c) turn the obtained *OIS rate 2* into the *OIS discount factor 2* by employing the following formula: $OIS_{df2} = \frac{1}{(1+OIS\_rate\_2)^{\frac{(term\_date-t)}{365}}}$;
d) compute *spot date – t* in year fractions;
e) linearly interpolate from *OIS rates* at evaluation date *t* to obtain the *OIS rate 1* corresponding to *tenor spot date -t*;
f) turn the obtained *OIS rate 1* into the *OIS discount factor 1* by employing the following formula: $OIS_{df1} = \frac{1}{(1+OIS\_rate\_1)^{\frac{(spot\_date-t)}{365}}}$.

5 Treating Inflation-linked bonds (Linkers)

Inflation-linked bonds (*linkers*) are bonds whose coupons and principal are re-evaluated based on the trend of a specific inflation index. In particular, the following *linkers* are subject to margining according to the methodology outlined below:

[6] In this case accrual interests are computed at SSD (*spot settlement date*) also for both the market price component and the *R2* component. This is due to the fact that, unlike *repos*, the *spot* leg has yet to settle and a hypothetical close out *repo* would settle with accruals defined at *spot settlement* date. For the same reason, *R2* component for *forward starting repos* accrues for the entire trade duration (*term – spot*)*days*.

a) *BTP Italia*: Italian treasuries indexed to Italian ex-tobacco inflation (FOI);
b) *BTPi*: Italian treasuries indexed to European ex-tobacco inflation (CPTFEMU);
c) *SPGBei*: Spanish treasuries indexed to European ex-tobacco inflation (CPTFEMU);
d) French government bonds linked to *French ex-tobacco inflation* (HICP);
e) French government bonds linked to *European ex-tobacco inflation* (CPTFEMU);
f) German government bonds linked to *European ex-tobacco inflation* (CPTFEMU).

The same logic outlined in the previous paragraphs for the calculation of the *Mark-to-market Margin* still applies. However, formulas (1), (2), (3), (4) and (5) must be amended as follows:

***Cash* positions – *Mark-to-market Margin*:**

$$(6)\ MtM_{margin} = N * \left(\frac{P_{market} + AI_{SD}}{100} * CI_{SD} - \frac{P_{trade} + AI_{SD}}{100} * CI_{SD}\right) * ps;$$

***Repo* positions – *Mark-to-market Margin*:**

$$(7)\ MtM_{margin} = (N * \left(\frac{P_{market} + AI_{E1D}}{100} * CI_{E1D} - \frac{P_{trade} + AI_{SSD}}{100} * CI_{SSD}\right) - (R1 - R2)) * OIS_{disc\_factor} * ps;$$

$$(7.1)\ R1 = \frac{(term\_date - spot\_date)_{days} * (\frac{P_{trade} + AI_{SSD}}{100}) * CI_{SSD} * N * repo\_rate\_1}{36000};$$

$$(7.2)\ R2 = \frac{(term\_date - t)_{days} * (\frac{P_{market} + AI_{E1D}}{100}) * CI_{E1D} * N * repo\_rate\_2}{36000};$$

***Forward starting repo* positions – *Mark-to-market Margin*:**

$$(8)\ MtM_{margin} = ((N * \left(\frac{P_{market} + AI_{SSD}}{100} * CI_{SSD} - \frac{P_{trade} + AI_{SSD}}{100} * CI_{SSD}\right)) * (OIS_{df2} - OIS_{df1}) - (R1 - R2) * OIS_{df2}) * ps,$$

$$(8.1)\ R1 = \frac{(term\_date - spot\_date)_{days} * (\frac{P_{trade} + AI_{SSD}}{100}) * CI_{SSD} * N * repo\_rate\_1}{36000};$$

$$(8.2)\ R2 = \frac{(term\_date - spot\_date)_{days} * (\frac{P_{market} + AI_{SSD}}{100}) * CI_{SSD} * N * repo\_rate\_2}{36000};$$

where $\frac{P_{trade} + AI_{SD}}{100} * CI_{SD}$ and $\frac{P_{trade} + AI_{SSD}}{100} * CI_{SSD}$ are directly available in the trade contract, AI_{E1D} has already been discussed in the previous paragraphs and CI_{E1D} must be computed following the steps below:

Base index definition:

Inflation-linked bonds (CPTFEMU):

Assuming the *issue date* of the *linker* is the 4th of May 2017, the two relevant dates for computing the *base index* are March 2017 (2 months earlier than the *issue date*) and February 2017 (3 months earlier than the *issue date*).

Consider the following CPI (FOI or CPTFEMU depending on the *linker*) time series:

Date	CPI
02 - 2017	100,77
03 - 2017	101,59

The *base index* at *issue date* (4th of May 2017) is computed according to the following formula:

(9) $base_{index} = index_{m-3} + \frac{(d-1)}{days\_month} * (index_{m-2} - index_{m-3})$,

with $index_{m-2}$: 101,59; $index_{m-3}$: 100,77; d-1: *issue date*–1 day (in this case equal to 3) and days_month: number of days in the issue month (in this case equal to 31).

Inflation-linked bonds (FOI):

For Italian linkers the same as described above is applied, with the exception that instead of the issuance date of the bond the last coupon date previous to the evaluation date is considered.

Current index definition:

In order to compute the *current index* it is necessary to employ formula (9) with d: *settlement* / evaluation date + 1 business day (settlement date for *cash* trades and evaluation date + 1 business day for *repo* trades). The reference data for $index_{m-2}$ and $index_{m-3}$ is in this case the date which is 2 months / 3 months respectively prior to evaluation date + 1 business day.

Inflation coefficient CI_{E1D} definition:

$$CI_{E1D} = \frac{current_{index}}{base_{index}}.$$

6 Numerical examples

Below are some numerical calculation examples relating to what outlined in the previous sections.

6.1 Calculating M*ark-to-market Margin* for *cash* positions – numerical example

POSITION TYPE	CASH
POSITION	L
CURRENCY	EUR
TRADE DATE	13 / 04 / 2018
SETTLEMENT DATE	17 / 04 / 2018
EVALUATION DATE	16 / 04 / 2018
PRINCIPAL	35.000.000
CURRENT *CLEAN* MARKET PRICE	101,81
DIRTY TRADE PRICE	102,13
ACCRUED INTEREST AT SETTLEMENT DATE	0,2999

Formula (1) is applied:

$$MtM_{margin} = 35.000.000 * \left(\frac{101{,}81+0{,}2999}{100} - \frac{102{,}13}{100}\right) * 1.$$

As a result, the Clearing Member has a debt equal to 6.372,84 €.

6.2 Calculating M*ark-to-market Margin* for *repo* positions – numerical example

POSITION TYPE	REPO
POSITION	L
CURRENCY	EUR
TRADE DATE	13 / 04 / 2018
SPOT LEG SETTLEMENT DATE	16 / 04 / 2018
TERM LEG SETTLEMENT DATE	19 / 04 / 2018
EVALUATION DATE	18 / 04 / 2018
PRINCIPAL	19.000
CURRENT *CLEAN* MARKET PRICE	115,44
DIRTY TRADE PRICE	116,00
REPO RATE	0,50
ACCRUED INTEREST AT EVALUATION DATE + 1 BD	0,6196

Formula (2) is applied:

$$R1 = \frac{3 * \frac{116}{100} * 19.000 * 0,50}{36000} = 0,9183529.$$

Consider the following term structure of the *OIS/EONIA spot curve* on the 13th (*trade date*) and 18th (evaluation date *t*) of April 2018:

	O/N (1 day)	1W (7 days)
13/04/2018	-0,365	-0,338
18/04/2018	-0,364	-0,354

The maturity of the *original repo trade* is equal to 3 days (19/04/2018 – 16/04/2018). It is therefore needed to linearly interpolate from O/N and 1W nodes of the *OIS/EONIA spot curve* at *trade date* in order to obtain the relative *OIS rate*:

original_OIS_rate = -0,365 + (-0,338 + 0,365) * (3 - 1) / (7 - 1) = -0,356.

The *original OIS spread* is thus equal to 0,50 + 0,356 = 0,856.

The maturity of the *closing repo trade* is equal to 1 day (19/04/2018 – 18/04/2018). The relative *OIS rate* at evaluation date is therefore equal to -0,364. The *repo rate 2* is thus equal to -0,364 + 0,856 = 0,49.

Formula (3) is then applied:

$$R2 = \frac{1 * \frac{(115,44 + 0,6196)}{100} * 19.000 * 0,49}{36000} = 0,3013680.$$

It is then necessary to compute the *OIS discount factor* from *term date* to evaluation date *t*:

$$OIS_{discount\_factor} = \frac{1}{(1-0,364)^{\frac{1}{365}}} = 1,00001.$$

Formula (4) is finally applied in order to compute the *Mark-to-market Margin*:

$$MtM_{margin} = (19.000 * \left(\frac{115,44+0,6196}{100} - \frac{116}{100}\right) - (0,9183529 - 0,3013680)) * 1,00001 * 1.$$

As a result, the Clearing Member has a credit equal to 10,23 €.

6.3 Calculating M*ark-to-market Margin* for *forward starting repo* positions – numerical example

POSITION TYPE	FORWARD STARTING REPO
POSITION	L
CURRENCY	EUR
TRADE DATE	16 / 04 / 2018
SPOT LEG SETTLEMENT DATE	20 / 04 / 2018
TERM LEG SETTLEMENT DATE	27 / 04 / 2018
EVALUATION DATE	18 / 04 / 2018
PRINCIPAL	29.000.000
CURRENT *CLEAN* MARKET PRICE	99,99
DIRTY TRADE PRICE	99,89
REPO RATE	0,325
ACCRUED INTEREST AT SSD	0,0004

Formula (2) is applied:

$$R1 = \frac{7 * \frac{99{,}89}{100} * 29.000.000 * 0{,}325}{36000} = 1.830{,}627.$$

Consider the following term structure of the *OIS/EONIA spot curve* on the 16th (*trade date*) and 18th (evaluation date *t*) of April 2018:

	O/N (1 day)	**1W (7 days)**	**2W (14 days)**
16/04/2018	-0,364	-0,353	-0,340
18/04/2018	-0,364	-0,354	-0,352

The maturity of the *original repo trade* is equal to 7 days (27/04/2018 – 20/04/2018). The *original OIS rate* is therefore equal to -0,353.

The *original OIS spread* is thus equal to 0,325 + 0,353 = 0,678.

The maturity of the *closing repo trade* is also equal to 7 days (it is always between *term* and *spot* date, being a *forward starting repo*). The relative *OIS rate* at evaluation date is therefore equal to -0,354. The *repo rate 2* is thus equal to -0,354 + 0,678 = 0,324.

Formula (3) is then applied:

$$R2 = \frac{7 * \frac{(99{,}99 + 0{,}0004)}{100} * 29.000.000 * 0{,}324}{36000} = 1.826{,}825.$$

It is then necessary to compute the two *OIS discount factors* from *term date* to evaluation date *t* and from *spot date* to *t* by employing the *OIS/EONIA spot curve* at *t*. As *spot date – t* is equal to 2 days and *term date – t* is equal to 9 days, one obtains:

OIS_rate_1 = -0,364 + (-0,354 + 0,364) * (2 - 1) / (7 - 1) = -0,362;

OIS_rate_2 = -0,354 + (-0,352 + 0,354) * (9 - 7) / (14 - 7) = -0,353,

and thus:

$$OIS_{df1} = \frac{1}{(1\text{-}0{,}362)^{\frac{2}{365}}} = 1{,}00001;$$

$$OIS_{df2} = \frac{1}{(1\text{-}0{,}353)^{\frac{9}{365}}} = 1{,}00008\ .$$

Formula (5) is finally applied in order to compute the *Mark-to-market Margin*:

$$MtM_{margin} = ((29.000.000 * \left(\frac{99{,}99+0{,}0004}{100} - \frac{99{,}89}{100}\right))*(1{,}00008\text{-}1{,}00001)\text{-}(1.830{,}627\text{-}1.826{,}825)*1{,}00008)*1.$$

As a result, the Clearing Member has a credit equal to 1,846 €.