In the Balance

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Abstract

Funding costs and counterparty credit risk adjustments have become increasingly important contributions to the total value of derivatives positions. Based on a recently developed derivatives pricing framework that incorporates these two effects in a unified way, we discuss the relationship of the funding cost adjustment to the balance sheet. We also demonstrate two ways in which the funding cost adjustment can be eliminated, resulting in symmetric derivatives values.

1 Introduction

Funding costs and bilateral counterparty credit risk of derivatives positions have become increasingly hot topics since the geninning of the credit crisis in 2008. It has become standard practise to adjust derivatives prices for the counterparty risk. Similarly, funding costs are increasingly incorporated into derivative prices one way or another, but the conceptual foundations for such funding adjustments are much less well understood.

Piterbarg [1] showed, how funding costs of the delta hedging strategy impact the derivatives pricing. Subsequently, Burgard and Kjaer [2] have developed a unified framework that combines funding costs and bilateral counterparty credit risk. This framework specifies, how a positive cash account related to the hedging strategy of an uncollateralised derivative can be used to fund the repurchase of the issuer's own bonds in order to hedge out its own credit risk. This demonstrates that the debt value adjustment (DVA) is equivalent to a funding benefit adjustment and justifies its inclusion in a bilateral counterparty value adjustment. The framework also includes the funding costs associated with a negative cash account, and yields a corresponding additional adjustment to the derivatives price, the funding cost adjustment (FCA).

In both papers of Piterbarg [1] and Burgard and Kjaer [2], the size of the funding cost adjustment depends on the specific way the funding is achieved and thus gives rise to prices that are dependent on the funding position of the issuer. The counterparty would clear the price with the issuer with the best funding position.

This present paper shows that the funding cost term is related to a windfall to the issuer's bondholders upon default of the issuer. This leads us to examine the impact of the derivative asset and funding positions on the balance sheet within a simple balance sheet model. We show that this impact on the balance sheet and the overall funding position of the issuer reduces the effective marginal funding spread for the new positions to zero. We then discuss two strategies of how the balance sheet impact can directly be neutralised, mitigating the need for a funding cost adjustment to the derivatives price. If such strategies can be put into practice, they lead back to a state where symmetric prices between issuer and counterparty are achieved.

2 Review of the unified framework for bilateral counterparty risk and funding adjustments

To set the stage for the following discussions, we review and interpret the framework of Burgard and Kjaer [2]. In this framework, we consider an uncollateralised derivative on an underlying asset S between an issuer B and a counterparty C[1]. The "risk-less" value $V(S,t)$ shall be the counterparty-credit-risk free and funding-cost free value, as seen from the issuer, of the derivative at time t. The "risky" value $\hat{V}$, in contrast, is defined to include these effects[2].

[1] The arguments presented here can easily be extended to include collateralised trades.

[2] As such, $\hat{V}$ is, at the start of the trade, minus the premium that the counterparty pays to the issuer and, during the live of the trade, minus the cash account of the hedging strategy of the issuer as discussed later.

The underlying processes for the asset process S and the zero-recovery bonds P_B and P_C of the issuer and counterparty, respectively, are asssumed to follow lognormal process for S and independent jump-to-default prosseses dJ_B and dJ_C for the issuer and countparty, respectively:

$$\frac{dS}{S} = \mu dt + \sigma dW \tag{1}$$

$$\frac{dP_B}{P_B} = r_B dt - dJ_B \tag{2}$$

$$\frac{dP_C}{P_C} = r_C dt - dJ_C \tag{3}$$

The jump-to-default processes J_B and J_C jump from 0 to 1 upon default of the issuer and counterparty, respectively. For simplicity, the framework assumes deterministic rates and default intensities. As such, it does not include any convexity effects between funding rates and market factors, as discussed in Piterbarg [1], but could be extended to do so.

The bonds P_B and P_C are zero-recovery bonds for simplicity. Zero-recovery bonds together with risk free assets can be used as building blocks to replicate more complicated structures, e.g. bonds with recovery. In Section 6, we will consider a case where we include bonds of different seniority (and therefore recovery) in order to neutralise the balance sheet impact of the derivatives.

The boundary condition of the risky value of the derivative $\hat{V}(S, t, J_B, J_C)$ upon default of the issuer or counterparty are defined as

$$\begin{array}{rcll} \hat{V}(t, S, 1, 0) & = & M^+(t, S) + R_B M^-(t, S) & \text{B defaults first} \\ \hat{V}(t, S, 0, 1) & = & R_C M^+(t, S) + M^-(t, S) & \text{C defaults first} \end{array} \tag{4}$$

Contractual details will determine, which values for the close-outs M should be used upon default of the issuer or counterparty. In this present paper, we only consider the case $M = V(t, S, 0, 0)$ as it more closely describes contracts that follow the ISDA master agreements of 1992 and 2002.[3]

The framework is based upon a replication strategy of holding δ amounts of the underlying asset S, α_C amounts of the zero-recovery bonds P_C of the counterparty, and $\beta(t)$ amounts of cash. This cash, if positive, is used to fund the (re-)purchase of the required number α_B of the issuer's own zero-recovery bonds P_B, such that the issuer's credit risk on the derivative position is hedged out. Any remaining cash $\beta_F = -\hat{V} - \alpha_B P_B$, if positive, is being used to purchase risk-free assets (yielding rate r), so as not to spoil this hedge position, and, if negative, is financed from an external funding provider at a funding rate r_F. The cost of this funding is included in the cost of the hedging strategy and therefore the risky value $\hat{V}$. It shall be noted, that while the risk of the issuer's default on the derivative contract is hedged out by the replication strategy, the risk of the funding provider to the issuer's credit is not, and the funding provider correspondingly earns the spread $s_F = r_F - r$ as compensation for this risk. The hedge ratios found in Burgard and Kjaer [2] for the $M = V$ case are:

[3] Albeit even with these agreements uncertainties remain with respect to the inclusion of funding costs and own credit adjustment (alias DVA) of the non-defaulting party in the calculation of the close-out amount, as well as the potential inclusion of set-offs against other obligations between the counterparties.

$$\begin{aligned}
\delta &= -\partial_S V - \partial_S U, & (5)\\
\alpha_B &= -\frac{U + (1 - R_B)V^-}{P_B}, & (6)\\
\alpha_C &= -\frac{U + (1 - R_C)V^+}{P_C}, & (7)\\
\beta_F &= -V^+ - R_B V^-, & (8)
\end{aligned}$$

where $U = \hat{V} - V$ is the total adjustment.

The replication strategy with these hedge ratios is self financing and result in the following PDE for the risky value of the derivative:

$$\begin{cases} \partial_t \hat{V} + \mathcal{A}_t \hat{V} - (r + \lambda_B + \lambda_C)\hat{V} = -(R_B \lambda_B + \lambda_C)V^- - (\lambda_B + R_C \lambda_C)V^+ + s_F V^+ \\ \hat{V}(T, S) = H(S). \end{cases} \tag{9}$$

where

$$\begin{aligned}
\mathcal{A}_t V &\equiv \frac{1}{2}\sigma^2 S^2 \partial_S^2 V + (q_S - \gamma_S) S \partial_S V & (10)\\
s_F &\equiv r_F - r & (11)\\
\lambda_B &\equiv r_B - r & (12)\\
\lambda_C &\equiv r_C - r & (13)
\end{aligned}$$

and q_S is the net share position financing cost and γ_S is the dividend income.

This then yields the integral representation

$$U(t, S) = CVA + DVA + FCA \tag{14}$$

with

$$\begin{aligned}
CVA &= -(1 - R_C) \int_t^T \lambda_C(u) D_{r+\lambda_B+\lambda_C}(t, u) \mathbb{E}_t \left[V^+(u, S(u))\right] du & (15)\\
DVA &= -(1 - R_B) \int_t^T \lambda_B(u) D_{r+\lambda_B+\lambda_C}(t, u) \mathbb{E}_t \left[V^-(u, S(u))\right] du & (16)\\
FCA &= -\int_t^T s_F(u) D_{r+\lambda_B+\lambda_C}(t, u) \mathbb{E}_t \left[V^+(u, S(u))\right] du. & (17)
\end{aligned}$$

The first term is often referred to as the (modified) unilateral CVA, the second term as the DVA and the third term is a funding cost adjustment, which we shall call FCA. It is clear from this representation that while both, the DVA as well as the FCA are related to the credit position of the issuer, they do not double count the issuer's credit but capture exposures of the mark-to-market value of the derivative of opposite sign and as such are opposite sides of the same coin. The DVA term itself can be seen as a funding benefit term, as it arises from the issuer using a positive cash account to buy back his own bonds, earning the spread on it while at the same time hedging out its own credit risk on the derivative position.

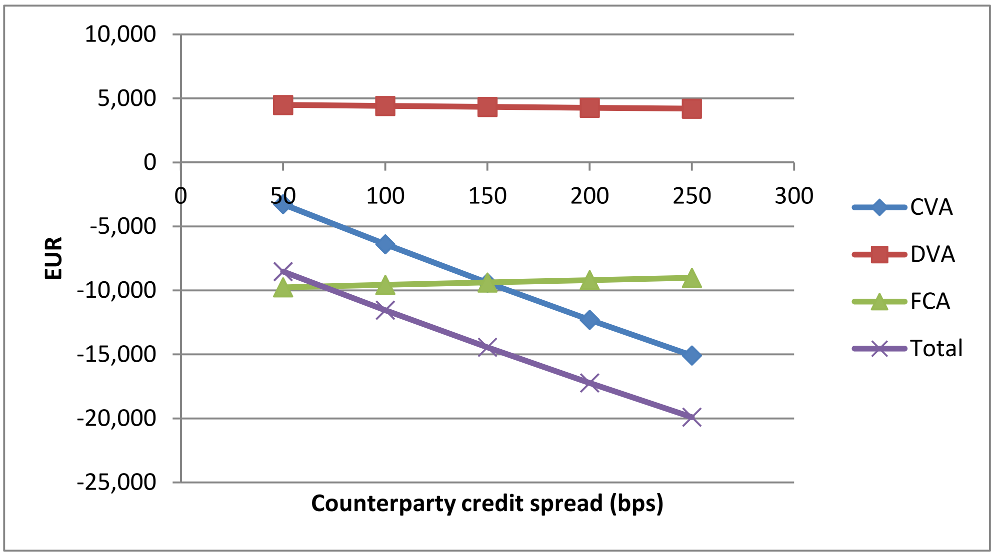

Figure 1: CVA, DVA, FCA and total adjustment U as a function of the counterparty credit spread. Issuer spread is 150bp.

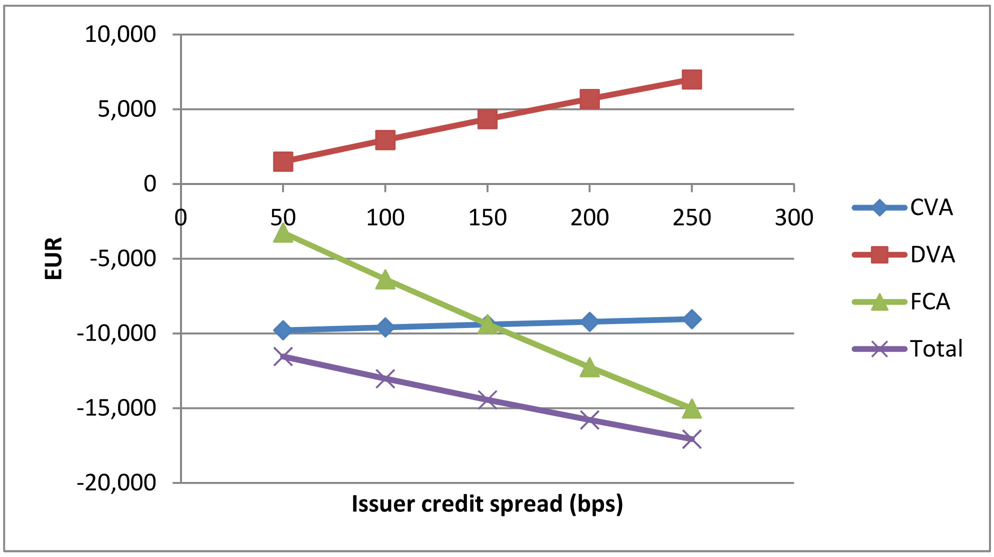

Figure 2: CVA, DVA, FCA and total adjustment U as a function of the issuer credit spread. Counterparty spread is 150bp.

Figures 1 and 2 display the value of the CVA, DVA and FCA corrections as well as the total correction U as a function of the counterparty and issuer credit spreads for a 5y quarterly paying fixed float swap of EUR10m notional with present value $V = 0$.

Equation (14) deserves some further discussions and interpretations.

First, it should be noted, that the hedging strategy leading to this equation involves the issuer repurchasing its own bonds. It does not involve any dealings in its own CDS. The term λ_B is the spread of the yield of a zero-recovery bond over the risk free rate. It is not the hazard rate derived from the CDS market. Thus, if there is a basis between bonds and CDS for the issuer B, it is the bond market that counts for determining λ_B used in the DVA and FCA terms in equations (16) and (17).

Second, it is instructive to discuss the hedge ratios obtained in equations (5) to (8). For negative V (i.e. positive cash account -V), the combination of zero-recovery zero-coupon bonds of value $-(1 - R_B)V^-$ and $-R_B V^-$ amount of cash invested in risk free assets, replicates an investment of value $-V^-$ in a zero-coupon bond with recovery R_B [4]. Thus, for the issuer to hedge its own credit risk on the risk free part V^- of the derivative value, it could as well invest the amount $-V^-$ in bonds with recovery R_B. The contributions of U to the hedge ratios, on the other hand, come from the fact that upon default the close-out amount of V differs from the (risky) value of the derivative just prior to default by the amount U, because the credit and funding adjustments for the trade disappear upon default of the counterparty or the issuer. Thus, the credit risk on the full amount of U needs to be hedged out, and this is achieved by means of taking positions in zero-recovery bonds of B and C corresponding to the full value of U.

Third, the spread s_F in the FCA term (17) is the spread paid for funding negative balances on the cash account.

Without the FCA term, the risky value $\hat{V}$ would be symmetric in B and C, i.e. the counterparty and the issuer, following the same methodology, would agree on the same price. If, however, the funding costs for the replication strategy are included and the funding spread is non-zero, then the two parties both hedging out their risks and pricing in their funding costs, would not agree on the price. A counterparty, that wants to buy this product would buy it from the issuer with smallest FCA term, i.e. the lowest funding costs.

In the following, we discuss the origins of the FCA term in more detail and show different ways of how the funding costs can be mitigated. Doing so successfully can reduce the FCA term to zero and produce prices, that are independent on the funding position of the issuer and are therefore symmetric.

3 Origin of the FCA term for unsecured funding of derivatives position

If the funding of the negative cash account is done unsecured, then s_F is the issuer's unsecured funding spread. Assuming the recovery upon issuer's default on the unsecured funding is R_B, i.e. the same as the recovery on the derivative's close-out amount, then the unsecured

[4] Where recovery is on the risk-free value.

funding spread s_F is related to the spread λ_B on the zero recovery bond via the relation $s_F = (1 - R_B)\lambda_B$ and the FCA term becomes

$$FCA \;=\; -(1 - R_B) \int_t^T \lambda_B D_{r+\lambda_B+\lambda_C}(t,u)\mathbb{E}_t\left[V^+(u, S(u))\right] du. \tag{18}$$

To understand the origin of this term, it is instructive to see what happens, when the issuer defaults while $\hat{V}$ is positive, i.e. in-the-money for the issuer. In this case, just prior to default, the cash account β_F is negative and its corresponding amount $-V^+$ is provided unsecured by the funding provider. If the issuer then defaults, its derivatives desk will settle the derivative at the close-out amount with the counterparty, i.e. receive V^+. The external, unsecured funding provider, on the other hand, will only receive $R_B V^+$ on his funding, so loosing $(1 - R_B)V^+$. Prior to default, the funding provider is compensated for this potential loss by receiving the spread s_F while the issuer is alive. The position of the issuer upon its own default, i.e. getting V^+ for the derivative and paying $R_B V^+$ to the funding provider, is a positive windfall of $(1 - R_B)V^+$, which goes towards the recovery of the bondholders of the issuer. Inspection of the FCA term in equation (18) shows that it is the expectation value of this windfall - it is the integral over λ_B, representing the probability density of the issuer to default, times $D_{\lambda_B+\lambda_C}$, the probability that none of the issuer and counterparty having defaulted up to that point, times the expected loss $-(1 - R_B)\mathbb{E}_t\left[V^+\right]$ to the funding provider upon default of the issuer, all discounted to t.

So the following picture arises: the FCA term of equation (18) is the premium for the "windfall" to the bondholders of the issuer in the case where the issuer defaults and the derivative has positive value for the issuer. This premium is a cost that arises while the issuer is alive. This cost is included in the derivatives value $\hat{V}$ charged to the counterparty by means of the funding cost term in equation (18).

4 Simple model for impact of derivates asset on balance sheet and funding

As discussed in the previous section, derivatives and their funding positions contribute to the asset and liability pools upon the issuer's default. Therefore, they themselve should impact the funding costs of the issuer. In this section, we will quantify this feedback effect using a simple balance sheet and funding model.

Assume that, as in a reduced form credit model, default of the issuer is driven by an instantaneous default process with default intensity λ. Prior to entering into the derivative contract, let A_0 be the expected assets upon default of the issuer and L_0 be the liabilities, so that the expected recovery upon default is $R_0 = A_0/L_0$. Within this simple setup, the funding spread s_F of the issuer over the risk free rate that compensates for the expected loss upon its default is $s_F = (1 - R_0)\lambda$. Thus, the instantaneous funding costs f_0 of the issuer over time $\mathrm{d}t$ for his total liabilty L_0 is

$$f_0 \mathrm{d}t = (r + (1 - R_0)\lambda)\, L_0 \mathrm{d}t \tag{19}$$

Let the issuer now add a derivative with positive value d as an asset, resulting in total assets of $A_1 = A_0 + d$ [5], and fund the corresponding negative cash by adding a corresponding liability, giving new total liability of $L_1 = L_0 + d$. Thus, the expected recovery changes to

$$R_1 = \frac{A_1}{L_1} = \frac{A_0 + d}{L_0 + d} \tag{20}$$

Adding the derivatives asset, assuming the issuer has hedged the market and counterparty risk, does not change the default intensity of the issuer. Thus, the instantaneous funding costs after adding the derivatives are

$$\begin{aligned}
f_1 \mathrm{d}t &= (r + (1 - R_1)\lambda) L_1 \mathrm{d}t && (21)\\
&= r(L_0 + d)\mathrm{d}t + (L_1 - A_1)\lambda \mathrm{d}t && (22)\\
&= rL_0 \mathrm{d}t + r \cdot d \cdot \mathrm{d}t + (L_0 - A_0)\lambda \mathrm{d}t && (23)\\
&= r \cdot d \cdot \mathrm{d}t + r \cdot L_0 \cdot \mathrm{d}t + (1 - R_0)\lambda L_0 \mathrm{d}t && (24)\\
&= r \cdot d \cdot \mathrm{d}t + f_0 dt && (25)
\end{aligned}$$

Thus, the effective cost of funding for the additional liability d is $r \cdot d \cdot \mathrm{d}t$. While the new liability d draws the new funding spread $(1 - R_1)\lambda$, the change on the recovery and its effect on the funding of the total liabilies results in an effective funding rate for d that is the risk free rate. Thus, within this balance sheet model the spread s_F is zero.

While this balance sheet model is somewhat simplistic, it shows, that proper accounting for the effects of the derivative assets on the balance can mitigate the funding costs and bring the FCA term down to zero. With a vanishing FCA term, equation (14) yields an adjustment U and risky value $\hat{V}$ that are symmetric between issuer B and counterparty C. Practically, however, the challenge is an operational one, in that the benefit of the balance sheet impact is difficult to pin down at the moment of trading and hedging the derivative contract and therefore difficult to allocate as a benefit to the derivatives trading desk.

In the following, we will in thus discuss two mechanisms, that shield the balance sheet from the impact of the derivative asset and funding liability and lower the funding costs directly.

5 Case where derivative can be used as collateral

As already mentioned in Burgard and Kjaer [2], the derivative itself could be used as collateral for the funding required for negative balances on the cash account. The cash account is negative when the derivative has positive value to the issuer. It could be ring-fenced from the other assets and used as security for the required funding. To be precise, the negative cash balance β_F that needs funding is $-V^+$, i.e. minus the risk-free value of the derivative, if V is positive. While the value of the derivative to the issuer is the risky value $\hat{V}$, its close-out value is the riskless value V, so it could indeed be used to secure the required amount of funding of V if no haircut were applied.

In practise, there are a number of technical difficulties to be taken into account when considering whether and how the derivative could be used as collateral. One of them is that the value of the derivative (and the amount of cash requiring funding) changes constantly. Another one

[5] The positive value d to the issuer corresponds to $-V^-$ in our previous discussions.

is, that, in general, one should expect a healthy haircut to be applied between the value of the derivative collateral and the secured funding amount. Both of these practical difficulties could be mitigated to some extent by pooling derivatives assets together and obtain funding against this pool (or part of the pool). In the ideal (and theoretically clean) case, where the derivative can be used as collateral with zero haircut and the secured funding rate is the risk free rate, the spread s_F and, correspondingly, the FCA of equation (17) disappear and we are left with the first two terms for the adjustment U in equation (14), representing the usual bilateral CVA as described in many papers (e.g. see Gregory [3]), but its use being well justified in our framework through the hedging strategy of repurchasing the issuer's own bonds from its positive cash account. At the same time, since the derivative has been pledged as collateral when the cash accounts is negative, it does not appear as an asset on the balance sheet of the issuer.

6 Balance sheet management to mitigate funding costs

Another way to shield the balance sheet from the impact of the derivative asset and funding liabilities is to actively manage the balance sheet in such a way, that the windfall from the derivative asset and the funding position upon default of the issuer is balanced out by a corresponding liability.

This can be achieved if the issuer is able to freely trade two of its own bonds, P_1 and P_2, with different recovery rates R_1 and R_2, i.e. different seniority.

We thus change the setup from Section 2 such, that we have the hedging instruments P_1, P_2, P_C and S. All positive and negative cash in the cash account is invested and raised, respectively, by buying back and issuing P_1 and/or P_2 bonds. The assests follow the dynamics

$$\begin{cases} \frac{dP_1}{P_1} &= r_1(t)dt - (1-R_1)dJ_B \\ \frac{dP_2}{P_2} &= r_2(t)dt - (1-R_2)dJ_B \\ \frac{dP_C}{P_C} &= r_C(t)dt - dJ_C \\ \frac{dS}{S} &= \mu(t)dt + \sigma(t)dW, \end{cases} \tag{26}$$

where $R_1 \in [0,1)$, $R_2 \in [0,1)$ and $R_1 < R_2$. Neither of the recovery rates R_1 and R_2 need to equal the derivative recovery rate R_B.

As before we setup a replicating hedge portfolio Π given by

$$\Pi = \alpha_1 P_1 + \alpha_2 P_2 + \alpha_C P_C + \delta S + \beta_S + \beta_C, \tag{27}$$

where $\beta_S = -\delta S$ is the funding account for the share position and $\beta_C = -\alpha_C P_C$ is the funding position for the P_C-bonds. The fact that Π is meant to be a self-financing replicating hedge portfolio implies that

$$\Pi = \alpha_1 P_1 + \alpha_2 P_2 = -\hat{V} \tag{28}$$

$$d\Pi = -d\hat{V}, \tag{29}$$

so repeating the delta hedging arguments of Burgard and Kjaer [2] and defining $s_1 = r_1 - r$ and $s_2 = r_2 - r$ yield

$$
\begin{aligned}
\delta &= -\partial_S \hat{V} && (30)\\
\alpha_1(1-R_1)P_1 + \alpha_2(1-R_2)P_2 &= \Delta\hat{V}_B && (31)\\
\alpha_C P_C &= \Delta\hat{V}_C && (32)\\
\alpha_1 s_1 P_1 + \alpha_2 s_2 P_2 + \alpha_C\lambda_C P_C &= -\partial_t\hat{V} - \frac{1}{2}\sigma^2 S^2 \partial_S^2 \hat{V} + r\hat{V} - (q_S - \gamma_S)S\partial_S\hat{V}, && (33)
\end{aligned}
$$

where $\Delta V_B = \hat{V}(t,S,1,0) - \hat{V}(t,S,0,0)$ and $\Delta V_C = \hat{V}(t,S,0,1) - \hat{V}(t,S,0,0)$, with $\hat{V}(t,S,1,0)$ and $\hat{V}(t,S,0,1)$ given in equation (4) with $M = V$.

From these equations we can determine α_1 and α_2 to be

$$
\begin{aligned}
\alpha_1 &= -\frac{R_2\hat{V} - V^+ - R_B V^-}{(R_2 - R_1)P_1} && (34)\\
\alpha_2 &= -\frac{-R_1\hat{V} + V^+ + R_B V^-}{(R_2 - R_1)P_2}, && (35)
\end{aligned}
$$

which implies the following pricing PDE

$$
\partial_t\hat{V} + \mathcal{A}_t\hat{V} - r\hat{V} = s_1\frac{R_2\hat{V} - V^+ - R_B V^-}{R_2 - R_1} + s_2\frac{-R_1\hat{V} + V^+ + R_B V^-}{R_2 - R_1} - \lambda_C(V^- + R_C V^+ - \hat{V}). \tag{36}
$$

If we furthermore assume zero basis between the bonds (i.e. $s_1 = (1-R_1)\lambda_B$ and $s_2 = (1-R_2)\lambda_B$), then (36) simplifies to

$$
\partial_t\hat{V} + \mathcal{A}_t\hat{V} - (r + \lambda_B + \lambda_C)\hat{V} = -(R_B\lambda_B + \lambda_C)V^- - (\lambda_B + R_C\lambda_C)V^+. \tag{37}
$$

Comparing this to equation (9) implies financing of the negative cash account at vanishing spread $s_F = 0$. In particular, the strategy involves issuing the senior P_2-bonds and use some of the proceeds to re-purchase the junior and hence higher yielding P_1-bonds. The excess return generated by this strategy exactly offsets the additional funding costs, so the net-financing rate becomes r. At the same time, the combined position of P_1 and P_2 bonds ensures that there is is no windfall to the bondholders in the case of default of the issuer while V is positive (and the cash account negative). This is shown in Table 1, which summarises the total bond position at the issuers own default and which offsets perfectly the value of the derivative as defined in equation (4).

P_1-position value	$-\frac{R_1R_2\hat{V} - R_1V^+ - R_1R_BV^-}{R_2-R_1}$
P_2-position value	$-\frac{-R_2R_1\hat{V} + R_2V^+ + R_2R_BV^-}{R_2-R_1}$
Total position value	$-(V^+ + R_BV^-)$

Table 1: Value of the issuer's P_1 and P_2 bond positions post own default.

So if the issuer is able to offset the impact of the derivative and its funding on the balance sheet with a combination of going long senior bonds and short junior bonds, then the windfall is effectively monetized while the issuer is alive and by doing so the funding cost term is reduced to zero.

7 Conclusions

The inclusion of funding cost adjustments in derivative prices leads to issuer dependent prices. We have shown that the funding cost adjustment is related to the impact of the derivative and corresponding funding positions on the balance sheet upon the issuers default and have demonstrated ways, how this impact can be mitigated. Being able to follow any of these strategies will allow an issuer to price derivatives without a funding cost adjustment and leads to prices that are symmetric between issuer and counterparty.

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