Funding Value Adjustment (FVA)*

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Abstract

This paper reviews the concept of fair valuation in relation to adjustments that could arise due to counterparty default risk and funding needs. It is shown that the cost of funding from the market does not play any role in the fair valuation of the firm's OTC portfolios. Its main role is to offset the market-facing credit benefit (DVA). Therefore, adjusting the OTC trades using modified discount curves which incorporates the firm's financing cost is inaccurate.

1 Introduction

In order to carry a trade, one needs money. This funding is not only for the initial cost, or premium, of the trade but also for having the ability to pay all the associated cash flows, and collateral amounts, for the duration of its life. For dealers, in particular, the cost of funding is one of the challenges of remaining competitive. Recently, this has been the case specially in regards to the collateralized relationships, both bilateral and unilateral. Effect of collateral on the funding cost of the OTC positions has already been addressed [1] while the relationship between the funding cost and the counterparty risk has also been considered [2]. Currently, market quotes, for many vanilla

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trades, do include the effect of funding in the bilateral collateralized trades [3].
Funding cost has become such a driving force that many dealers have rapidly moved towards modifying their official discounting curves to reflect their funding cost [4]. However, how to handle the funding cost is, still an open debate. Should the cost of funding, which is an operation defined on the portfolio level, be applied to each single trade, through discounting of cash flows? Should the evaluation that the clients receive from their pricing agent, after the inclusion of CVA, *still* reflect the agent's credit worthiness? looking from the dealer's perspective, will it still need the funding, should its client default? Therefore, should these new discounting curves be counterparty specific? These questions go beyond differentiating between the funding cost and the credit benefit[1] (DVA). They reflect a need for a deeper understanding of funding cost and its relationship to fair valuation.
This paper attempts to address three, perhaps more fundamental, questions: 1) Is the funding cost a fair value adjustment? 2) If not, what is it? and 3) how to calculate it?
Answer to these three questions would shed light on a number of ambiguities mentioned above. For example, if the funding cost is not a fair value adjustment, as this paper promotes, since the client-facing credit benefit is, funding cost would be different from credit benefit. Furthermore, as the pricing agents should provide the market value of the trades to their clients, the funding cost should not be incorporated in the price of the trades. This view does not preclude the dealers from passing-on their funding cost on to their client. However, if they choose to do so, it should not be under the market valuation of the trades.
The rest of the paper is organized as follows. In section 2 funding value adjustment (FVA), in its general form, is looked at. Section 3 provides a methodology for calculating the funding cost facing the market. In Section 4, to better illustrate the methodology, a simple numerical example is provided. Section 5 provides a summary and concluding remarks.

[1] In order to remain consistent with the terminology used for other fair value adjustments in this paper, the term credit benefit, instead of DVA, is used.

2 Fair Value Accounting and Bilateral Adjustments For OTC Positions

In an economy with an infinite liquidity and a market quote for every asset and no bid and ask spread, any element in a balance sheet drives its value from two main sources: 1) a collection of drivers transparent to all market participants, called market, and 2) sources specific to the firms themselves. While market drivers are straight forward to measure, the firm-specific drivers are much more subject to interpretation of what the value is and how much of it is there.

Crudely speaking, fair value accounting was established to address concerns similar to these by setting the accounting and valuation standards in order to render the balance sheet more transparent [5, 6] to all market participants. Financial Accounting Standards No. 157 (FAS 157) [6], for example, requires the value of all financial instruments to be *adjusted* to reflect the price[2] "that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants". This means that for a bilateral commitment, between a firm and its k^{th} counterparty, the fair value of their OTC portfolio, $\overline{V}_k(t)$, is related to its market value, $V_k(t)$, through

$$\begin{aligned} \text{Market Value}+\text{Fair Value Adjustment } &= \text{Fair Value} \\ V_k(t) + \Delta_k &= \overline{V_k}(t). \end{aligned} \tag{1}$$

The adjustment Δ_k, in its general form, represents the total net fair value adjustment that a firm, should apply to its OTC positions based on the firm-specific values that each counterparty has towards another. Each adjustment should be composed of two elements: cost (always negative), representing a reduction in portfolio value, and a benefit (always positive), to represent an increase in portfolio value. Both adjustments are based on the firm's bilateral commitments with its k^{th} counterparty. The net value of the two components drives the net adjustment to be either positive or negative, i.e.

$$\Delta_k = \text{Benefit}_k + \text{Cost}_k \tag{2}$$

The purpose of Δ_k in (1) is to include the firm-specific adjustments in the market value of the portfolio. Its advantage, at the least, is that it is a

[2] The assumption of perfect liquidity has already paved the way to consider the exit and entry price of the asset to be the same price.

separate quantity; leaving $V_k(t)$ a firm independent value upon which all market participants can (and should) agree.
In fair value adjustment, conservation of value plays an important role. It basically dictates that one firm's benefit is its counterparty's cost, and *vice versa*. The concept of cost is rather intuitive. However, what constitutes benefit, while real, can be more subtle. In many cases, conservation of value is used to calculate a firm's benefit by obtaining counterparty's cost.

2.1 Credit Value Adjustment - CVA

An OTC portfolio bears the risk of the counterparty's default. From each counterparty's view, the portfolio can be seen as a cancellable portfolio. Economically, each firm has entered into three trades: 1) a default free portfolio, 2) a long option, bought from the counterparty, to cancel the portfolio if it defaults while the counterparty survives and 3) a short option, sold to the counterparty, to cancel the portfolio while the firm survives. Each option is cancellable for a final fee which would be equal to the recovery rate of the surviving counterparties' net positive exposure. As explained before, each fair value adjustment has two components. In this case, the sold option would be the credit cost, CC, and the bought option would be the credit benefit, CB, and the net of the two option values

$$CVA = CB + CC \tag{3}$$

is the bilateral credit value adjustment or CVA [7].

2.2 Funding Value Adjustment - FVA

The funding cost, FC, is the cost of funding above risk free rate. As mentioned in section 2, in order to preserve value, the same amount would be the funding benefit, FB, from the funding provider's view. Obviously, there are cases where this benefit (lender receiving a higher rate of return) needs to be offset with the credit risk that the lender has taken. In other cases, however, this funding benefit is a true benefit for which the provider needs to receive a premium. This, for example, would be the case of a firm, providing a funding benefit to its counterparty by paying a higher spread on the counterparty's cash collateral than the market [risk free] rate.
As per (3), FVA could now be defined as a net of cost, FC, and benefit, FB components

$$FVA = FB + FC \tag{4}$$

While CVA deals with the possible losses (and gains) due to at least one of the two counterparties' default, bilateral FVA would deal with the generated losses (and gains) while both firms survive. This makes CVA and the FVA, though driven by the same conditional default states, mutually exclusive.

2.3 CVA and FVA in a Simple Economy

Armed with fair valuation and its relationship to its corresponding market value through the fair value adjustment in (1), one can consider a simple economy composed of a firm, its counterparty and the market, under two discrete states. In both states, the firm has entered into OTC trades with its k^{th} counterparty, CP_k. It has, at the same time, entered into another transaction with the market, M, for the purpose of unsecured funding to address all its funding needs with CP_k, only. The same thing can be said for CP_k. The setup is presented in figure 1. The first state is the default "risk free" state. Thereofore, in this state of the economy both credit and funcding adjustments are zero. However, in the second state, "risky state", default risk is present.
At any given time, either the firm or its counterparty, CP_k, has the net funding needs, to source from the market, in order to carry their positions. With no loss of generality, one can assume that it is the firm.
The market, the unsecured lender for both counterparties, has two unique features:

1. Due to the fact that it is the market and, by definition, transparent to all participants, it has no fair value adjustments.

2. It never defaults and, therefore, only borrows at risk free rate[3].

In the risk free state, the firm has no adjustments. However, in the risky state, its total firm-level adjustments to CP_k would be due to two possible sources: M and CP_k. One adjustment would be allocated to each of the sources: one facing CP_k, Δ_k, and another facing M, $\Delta_{M,k}$. Hence, the firm's total fair value adjustment, in the risky economy, earmarked for k^{th} counterparty, is

[3]Note that perfect liquidity was already assumed at the beginning of section 2.

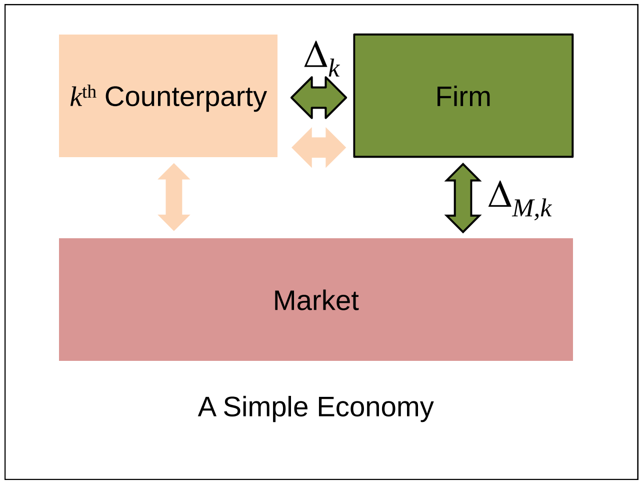

Figure 1: A simple economy composed of a firm, its counterparty and the market. The firm has entered into an OTC trade with CP_k and, at the same time, has borrowed money from Market to cover the position's funding needs. In the risky free state, Δ_k and $\Delta_{M,k}$ are both zero. Arrows represent bilateral financial commitments.

$$\Delta_k^{Firm} = \Delta_k + \Delta_{M,k} \tag{5}$$

The net adjustments from the market's point of view, due to the feature 1, is always 0. In order to preserve the conservation of value, the same adjustment from the firm's point of view should be

$$\Delta_{M,k} = 0 \tag{6}$$

which leads to

$$\Delta_k^{Firm} = \Delta_k. \tag{7}$$

Decomposing each of the adjustments in (5) further to their relevant CVA and FVA gives

$$\Delta_k = CVA_k + FVA_k \tag{8}$$

and

$$\Delta_{M,k} = CVA_{M,k} + FVA_{M,k}. \tag{9}$$

The terms $CVA_k = CB_k + CC_k$ and $FVA_k = FC_k + FB_k$ are the CVA and FVA, facing CP_k, respectively. The term $FVA_{M,k}$ represents the market-facing FVA for the unsecured borrowing (secured lending) of the firm, from (to) M, to carry its trades with CP_k. Similarly, the term $CVA_{M,k}$ is the market-facing CVA generated when unsecured borrowing (secured lending) the shortfall (excess) cash to carry its positions with CP_k. From (6),

$$CVA_{M,k} + FVA_{M,k} = 0. \tag{10}$$

Market, according to the feature 2, does not default nor it borrows above the risk free rate. Therefore, any transaction with the market creates no credit cost ($CC_{M,k} = 0$) nor any funding benefit ($FB_{M,k} = 0$) for the firm. In other words, in light of (3) and (4), (10) becomes

$$CB_{M,k} + FC_{M,k} = 0. \tag{11}$$

Furthermore, from (7) and (8),

$$\Delta_k^{Firm} = CVA_k + FVA_k \tag{12}$$

Equations (11) and (12) are the main results of this section.
Equation (12) states that the counterparty-facing CVA_k and FVA_k are the only adjustments to be applied to the firm's OTC trading activities with CP_k. Therefore, as (6) confirms, the funding cost, $FC_{M,k}$, due to unsecured borrowing from the market, to finance the OTC portfolio, does not contribute to the fair value adjustment of the portfolio. It only offsets $CB_{M,k}$. The credit benefit appears twice in the above two equations [(11) and (12)]. However, one credit benefit, CB_k, faces the counterparty in (12) and the other one, $CB_{M,k}$, in (11) is market-facing.

3 Calculation of $FC_{M,k}$

The fundamental ingredient for the calculation of $FC_{M,k}$ is the cash account used to manage the firm's funding needs to maintain its portfolio of trades with CP_k. The objective of this cash account, is to invest the shortfall, and deposit the excess cash, *after* netting all other bilateral cash in/outflow, CF, and collateral amount, $\dot{C}$. The assumption here is that the firm has settlement netting agreement with its counterparty. This means that only

the netted cash flows are to be paid out or received, which significantly reduces the funding needs.
The process starts at $t-\delta$ where the cash account CA is made up any funding amount (cash), $FA\,(t-\delta)$ and other cash flow, $CF(t-\delta)$ or collateral amount, $\dot{C}\,(t-\delta)$ that might have been paid (in or out), during the period δ.

$$CA(t-\delta) \equiv FA\,(t-\delta) + CF(t-\delta) + \dot{C}\,(t-\delta)$$

These three components of FA, CF and $\dot{C}$ can be seen as three different accounts maintained in three different departments of funding, settlement and collateral management units.
In the **risk free** state, the cash account receives financing on the same risk free rate, r, as it deposits. Over an infinitesimal period of δ, the cash account grows to become the new funding amount at t,

$$\begin{aligned} FA\,(t) &= e^{r\delta}\,[CA(t-\delta)]^{+} + e^{r\delta}\,[CA(t-\delta)]^{-} && (13) \\ &= e^{r\delta} CA(t-\delta) && (14) \end{aligned}$$

with $[x]^{\pm} \equiv \pm \max\,(\pm x, 0)$. Once at t, the cash account is reset to $CA(t) = FA\,(t) + CF(t) + \dot{C}\,(t)$ again and the process continues in the same fashion. The initial condition for (13) is $FA(t_0) \equiv -V_0$ reflecting the initial cost of the portfolio, and $CA(t_0) \equiv -FA(t_0) + CF(t_0) + \dot{C}\,(t_0)$.
On other hand, in the **risky** state, in carrying the true funding amount, $\dot{FA}\,(t)$, the cash account needs to be funded by the market's perception of the possible loss of the funding amount

$$\begin{aligned} \dot{FA}\,(t) &\equiv e^{r\delta}\,[CA(t-\delta)]^{+} \\ &\quad + e^{r\delta}\,[CA(t-\delta)]^{-}\,(\mathbf{1}_{\tau>t} + (1-LGD)\cdot \mathbf{1}_{\tau\leq t})\cdot \mathbf{1}_{\tau>t-\delta} \\ &= [FA\,(t)]^{+} + [FA\,(t)]^{-}\,(1 - LGD\cdot \mathbf{1}_{\tau\leq t})\cdot \mathbf{1}_{\tau>t-\delta} && (15) \end{aligned}$$

where $FA\,(t) = [FA\,(t)]^{+} + [FA\,(t)]^{-}$, (13) and $1 = \mathbf{1}_{\tau>t} + \mathbf{1}_{\tau\leq t}$, were used. The above illustrates that, regardless of its credit state, the firm is *always* entitled to its deposited cash, $[FA\,(t)]^{+}$, while it has an option to pay a $(1-LGD)$ fraction of what it owes, $[FA\,(t)]^{-}$, should it default. In the above equation, the credit state of the counterparty is absent. This reflects the concept that market has no knowledge of the final recipient of the fund.

The last cash flow of the portfolio at $t = T$ affects the initial cost of the trade, $FA(t_0)$, and consequently both $F\dot{A}(t)$ and $FA(t)$ throughout the life of the trade. Therefore, their dependence on T is understood.
Define $FC_T(t_1, t_2)$[4] as the value of the accrued funding cost of the portfolio from now until some future time t_2, measured at time t_1. The difference between $F\dot{A}(t)$ and $FA(t)$, conditional on both counterparties surviving until $t - \delta$, provides the change in the instantaneous market-facing cost of carry, $dFC_T(t,t)$, from $t - \delta$ to t.

$$
\begin{aligned}
& dFC_T(t,t) \\
&\equiv \left\{FA(t) - F\dot{A}(t)\right\} \cdot \mathbf{1}_{\tau,\tau_k > t-\delta} \\
&= \left\{FA(t) - \left[[FA(t)]^+ + [FA(t)]^- \left(1 - LGD \cdot \mathbf{1}_{\tau \le t}\right) \cdot \mathbf{1}_{\tau > t-\delta}\right]\right\} \cdot \mathbf{1}_{\tau,\tau_k > t-\delta} \\
&= \left\{[FA(t)]^- \left[1 - \left(1 - LGD \cdot \mathbf{1}_{\tau \le t}\right) \cdot \mathbf{1}_{\tau > t-\delta}\right]\right\} \cdot \mathbf{1}_{\tau,\tau_k > t-\delta} \\
&= [FA(t)]^- \left[\mathbf{1}_{\tau > t-\delta} + \mathbf{1}_{\tau \le t-\delta} - \left(1 - LGD \cdot \mathbf{1}_{\tau \le t}\right) \cdot \mathbf{1}_{\tau > t-\delta}\right] \cdot \mathbf{1}_{\tau,\tau_k > t-\delta} \qquad (16) \\
&= [FA(t)]^- \left[\left(LGD \cdot \mathbf{1}_{\tau \le t}\right) \cdot \mathbf{1}_{\tau > t-\delta} + \mathbf{1}_{\tau \le t-\delta}\right] \cdot \mathbf{1}_{\tau,\tau_k > t-\delta} \\
&= [FA(t)]^- \left[\left(LGD \cdot \mathbf{1}_{\tau \le t}\right) \cdot \mathbf{1}_{\tau > t-\delta}\right] \cdot \mathbf{1}_{\tau,\tau_k > t-\delta} \\
&= [FA(t)]^- \left[\left(LGD \cdot \mathbf{1}_{\tau \le t}\right) \cdot \mathbf{1}_{\tau > t-\delta}\right] \cdot \mathbf{1}_{\tau_k > t-\delta} \\
&= [FA(t)]^- \, LGD \cdot \mathbf{1}_{\tau \le t | \tau > t-\delta} \cdot \mathbf{1}_{\tau_k > t-\delta} \qquad (17)
\end{aligned}
$$

In (16), $1 = \mathbf{1}_{\tau > t-\delta} + \mathbf{1}_{\tau \le t-\delta}$ was used.
Closing the cash account after the last cash flow payment of the final remaining trade gives $FC_T(T + \delta, T) = 0$. The funding cost, $FC_T(0, T)$, under the forward measure, is given by

$$
\begin{aligned}
FC_T(0,T) &\equiv B(0,T)\,\mathbb{E}^T\left[FC_T(T,T)\right] \\
&= B(0,T)\,\mathbb{E}^T\left[\int_0^{FC_T(T,T)} dFC_T(t',t')\right] \\
&= B(0,T)\,\mathbb{E}^T\left[\int_\delta^T LGD \cdot [FA(t')]^- \cdot \mathbf{1}_{\tau \le t' | \tau > t'-\delta} \cdot \mathbf{1}_{\tau_k > t'-\delta}\right] \\
&= \int_\delta^T B(0,t')\,\mathbb{E}^{t'}\left[LGD \cdot [FA(t')]^- \cdot \mathbf{1}_{\tau \le t' | \tau > t'-\delta} \cdot \mathbf{1}_{\tau_k > t'-\delta}\right] \qquad (18)
\end{aligned}
$$

[4]From now on, the subscripts M and k are implicitly understood and are, therefore, omitted for ease of notation.

where $B(0,t')$ represents the risk free discount factor from now to t'. Equation (18) is the main result of this section.
Simplify the above further, the cumulative probabilities of survival of the firm, $Q(t)$, and of the counterparty, $Q_k(t)$, can be taken independent of each other and of the portfolio movements. Furthermore, one can assume a constant LGD for the firm. Breaking the portfolio life to N time horizons ($t_N = T$) where cash flow payments take place, one could approximate the integral in (18) with the summation

$$\begin{aligned} & FC_{t_N}(0,t_N) \\ \approx & \, LGD \sum_{i=1}^{N} B(0,t_i)\mathbb{E}^{t_i}\left[[FA(t_i)]^-\right] \left[Q\left(t_{i-1}\right) - Q\left(t_i\right)\right] \, Q_k\left(t_{i-1}\right), \end{aligned} \tag{19}$$

The funding amount $FA(t_i)$ can be related to the value of the portfolio. Purely for the purpose of simplifying the illustration, assume $\dot{C}(t) = 0$

$$\begin{aligned} FA(t_i) &= e^{r(t_i - t_{i-1})} CA(t_{i-1}) \\ &= e^{r(t_i - t_{i-1})} \left[FA(t_{i-1}) + CF(t_{i-1})\right] \\ &= e^{r(t_i - t_{i-1})} \left[e^{r(t_{i-1} - t_{i-2})} \left[FA(t_{i-2}) + CF(t_{i-2})\right] + CF(t_{i-1})\right] \\ &= \cdots \\ &= e^{rt_i} \left[-V(0) + \sum_{j=0}^{i-1} e^{-rt_j} CF(t_j)\right] \\ &= e^{rt_i} \left[-\sum_{j=1}^{N} e^{-rt_j} CF(t_j) + \sum_{j=0}^{i-1} e^{-rt_j} CF(t_j)\right] \qquad (20) \\ &= e^{rt_i} \left[CF(0) - \sum_{j=0}^{i-1} e^{-rt_j} CF(t_j) - \sum_{j=i}^{N} e^{-rt_j} CF(t_j) + \sum_{j=0}^{i-1} e^{-rt_j} CF(t_j)\right] \\ &= e^{rt_i} \left[CF(0) - \sum_{j=i}^{N} e^{-rt_j} CF(t_j)\right] \\ &= -\left[-e^{rt_i} CF(0) + \sum_{j=i+1}^{N} e^{-r(t_j - t_i)} CF(t_j) + CF(t_i)\right] \\ &= -\left[CF(t_i) + V(t_i) - e^{rt_i} CF(0)\right] \qquad (21) \end{aligned}$$

The appearance of the terms $CF(0)$ and $CF(t_i)$ are due to the fact that both $V(0)$ and $V(t_i)$ are exclusive of the cash flows paid at $t = 0$ and $t = t_i$, respectively. This is clearly shown in (20), for example, where the cash flow $CF(0)$ is not included in the first sum.

4 Example: Bullet Cash-flows

In order to get a feel for the calculation, in this section, (19) is applied to a set of of simple cash flows. The continuous compounding credit risk free rate is constant and deterministic at 50bp. The loss given default of the dealer, LGD, is 1 and the independent and instantaneous hazard rates for the dealer, h_d, and the counterparty, h_c, are at 50bp and 150bp, respectively. In this set up, (19) can further be simplified to

$$FC_{t_3}(0, t_3) = \sum_{i=1}^{3} B(0, t_i)\ [FA(t_i)]^{-}\ CRDT_k(t_i) \tag{22}$$

with

$$FA(t_i) \equiv -\left[CF(t_i) + V(t_i) - e^{rt_i} CF(0)\right] \tag{23}$$

and

$$CRDT_k(t_i) \equiv \left[Q\left(t_{i-1}\right) - Q\left(t_i\right)\right]\ Q_k\left(t_{i-1}\right) \tag{24}$$

Table 1 provides the formulas used for generating the numbers in the following tables. Tables 2 and 3 provide four scenarios. The only difference among these scenarios is the column CF_i. The results are generated from the Table 1. Each example provides two cash flows. While the second cash flow stays at 9 months, the first and the offsetting cash flow changes its date from now to 6 months time. The objective of the last two examples is to show the effect of the cash flow at the inception of the trade. Note that value of the portfolio, V_i, is the same for both examples. However, the funding cost, $FC_{t_3}(0, t_3)$, is drastically different.

5 Concluding Remarks

This paper reviewed the concept of fair value adjustments in relation to adjustments that could arise due to counterparty default risk and funding needs. Particularly, it answered three questions itemized at the beginning of this paper. The paper showed that the funding cost should not affect the value of OTC trades, it provided a formulation for its calculation and showed that its effect is to offset any benefit gained from its unsecured funding due to its credit deterioration.

References

[1] V. Peterbarg, “Funding Beyond Discounting: collateral agreements and derivatives pricing”, Risk, February, 2010

[2] M. Morini and A. Prampolini, “Risky funding: a unified framework for counterparty and liquidity costs”. *http://ssrn.com/ abstract=1669930*, and reference therein, 2010.

[3] W. Christopher, “The Price Is Wrong”, *Risk*, March, 2010

[4] W. Christopher, ”Dealing With Funding On Uncollateralized Swaps”, *Risk,* June, 2010.

[5] IASB, IAS 39 Financial Instruments: Recognition and Measurement, *http://www.iasb.org/NR/rdonlyres/1D9CBD62-F0A8-4401- A90D-483C63800CAA/0/IAS39.pdf*

[6] FASB, Summary of Statement No, 157, *http://www.fasb.org/summary/stsum157.shtml*

[7] J. Gregory, “Counterparty Credit Risk”, *John Wiley & Sons*, 2009

i	t_i	DF_i	CF_i	V_i	FA	$CRDT_i$	$\Delta FC_{t_3}(t_i, t_i)$
0	0.00	1.000	CF_0	$\sum_i^3 CF_i DF_i$	-	-	-
1	0.25	e^{-r*t_1}	CF_1	$\sum_{i=2}^3 CF_i DF_i / DF_{i-1}$	$-[CF_1 + V_1 - CF_0/DF_1]$	$1 - e^{-h_d t_1}$	$[FA_1]^- CRDT_1$
2	0.50	e^{-r*t_2}	CF_2	$CF_3 DF_3 / DF_2$	$-[CF_2 + V_2 - CF_0/DF_2]$	$\left[e^{-h_d t_1} - e^{-h_d t_2}\right] e^{-h_c t_1}$	$[FA_2]^- CRDT_2$
3	0.75	e^{-r*t_3}	CF_3	0	$-[CF_3 + V_3 - CF_0/DF_3]$	$\left[e^{-h_d t_2} - e^{-h_d t_3}\right] e^{-h_c t_2}$	$[FA_3]^- CRDT_3$
						$FC_{t_3}(0, t_3)$	$\sum_{i=1}^3 DF_i \Delta FC_{t_3(t_i, t_i)}$

Table 1: Formulas used to calculate the funding cost of four quarterly cash flows.

i	t_i	DF_i	CF_i	V_i	FA_i	$CRDT_i$	$\Delta FC_{M,k}(t_i,t_i)$
0	0	1	0	-2,492	2,492	-	-
1	0.25	0.998750781	0	-2,495	2,495	0.001249219	0
2	0.5	0.997503122	-2,000,000	1,997,502	2,498	0.001242989	0
3	0.75	0.996257022	2,000,000	0	-2,000,000	0.001236789	-2,474
						$FC_{M,k}(0,t_3)$	-2,464

(a)

i	t_i	DF_i	CF_i	V_i	FA_i	$CRDT_i$	$\Delta FC_{M,k}(t_i,t_i)$
0	0	1	0	-4,988	4,988	-	-
1	0.25	0.998750781	-2,000,000	1,995,006	4,994	0.001249219	0
2	0.5	0.997503122	0	1,997,502	-1,997,502	0.001242989	-2,483
3	0.75	0.996257022	2,000,000	0	-2,000,000	0.001236789	-2,474
						$FC_{M,k}(0,t_3)$	-4,941

(b)

Table 2: Calculation of $FC_{M,k}(0,t_3)$ using two different scenarios of different combinations of cash flows.

i	t_i	$DF(t_i)$	$CF(t_i)$	$V(t_i)$	$FA(t_i)$	$CRDT_k(t_i)$	$\Delta FC_{M,k}(t_{i,}, t_i)$
0	0	1	-2,000,000	1,992,514	-1,992,514	-	-
1	0.25	0.998750781	0	1,995,006	-3,997,508	0.001249219	-4,994
2	0.5	0.997503122	0	1,997,502	-4,002,508	0.001242989	-4,975
3	0.75	0.996257022	2,000,000	0	-4,007,514	0.001236789	-4,956
						$FC_{t_3}(0, t_3)$	-14,888

(a)

i	t_i	$DF(t_i)$	$CF(t_i)$	$V(t_i)$	$FA(t_i)$	$CRDT(t_i)$	$\Delta FC_{t_3}(t_{i,}, t_i)$
0	0	1	0	1,992,514	-1,992,514	-	-
1	0.25	0.998750781	0	1,995,006	-1,995,006	0.001249219	-2,492
2	0.5	0.997503122	0	1,997,502	-1,997,502	0.001242989	-2,483
3	0.75	0.996257022	2,000,000	0	-2,000,000	0.001236789	-2,474
						$FC_{t_3}(0, t_3)$	-7,430

(b)

Table 3: Calculation of $FC(0, t_3)$ using two different scenarios of three different combinations of quarterly cash flows. The objective of these two examples is to show the effect of the cash flow at the inception of the trade. Note that value of the portfolio is the same for both examples. However, the funding cost is drastically different.