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Too much XVA?

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Overview of the issues and model 1/3

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CVA and DVA have become standard and widespread adjustments since the GFC of 2008, adopted by the international accounting standards such us IFRS13. Even if DVA still raises some concerns due to the difficulty for dealers to effectively hedge the positions.

Others adjustments are more controversial and strongly discussed in the literature (see for example Hull&White in Risk 2012), but still widely adopted by practitioners in banks.

Banks, as highly levered entities, need to take into consideration the funding cost on a *going concern basis* and consequently they have adopted to various extents the internal practice of applying FVAs/MVAs to transactions. If the transaction generates a funding cost, banks want to trade at below fair value or receive a commission, if it produces a benefit they can also be willing to trade above fair or pay a commission.

Furthermore, banks are also regulated entity: regulators set various limits, the most important of which is the CET1 ratio*. Being capital a scarce resource, KVA as a new adjustment has become popular, even if less diffuse than CVA. In any case, virtually all banks calculate RAROC, which is closely linked to KVA, on business lines and transactions.

* other limits, such us LCR (liquidity covered ratio) and NSFR (Net Stable Funding Ratio) are also either recently introduced or are being introduced by CRR, and are relevant for the funding strategy and consequently for the FVA.

Overview of the issues and model 2/3

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Well before the diffusion of FVA, practically all banks have developed processes and methodology to allocate liquidity to business lines for their funding needs: usually through a central treasury and a FTP (Fund Transfer Pricing), which is the acronym for the internal cost of funds.

The methodology used to set the FTP is crucial: a bad designed FTP can create distortive incentives, penalize profitable businesses or create vicious feedback loops. FTP should instead being linked, among others**, to a good FVA model which in turn is tied to the funding strategy as we will see.

The model presented here is a dynamic one, and both FVA and KVA are marginal/differential values between before and after a certain investment is made by the entity. Both are dependent i) on the funding strategy and ii) on the diversification that the new asset introduces in the existing portfolio of the banks.

Despite the very simplified contest, the results are quite intuitive: if the bank's policy is to fund everything at maturity, the introduction of a well-diversified asset bears greater cost than a less diversified/volatile one, which can eventually produce a benefit. It can be seen as a paradox, but this is the old "*beggar-thy-neighbor*" policy applied to existing debtors.

** for example, to the various liquidity ratios introduced before.

Overview of the issues and model 3/3

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Furthermore, the absolute value of FVA/KVA is an increasing function of the liabilities' duration. This has important normative implications: if a bank wanted to reduce the riskiness of the portfolio by introducing less risky/more diversified asset, it would need to adopt a very short term funding policy. This is also quite rational, given the model's structure where investors set the funding cost looking at the asset side of the balance-sheet.

The previous considerations can be an answer to the question: 'can a high funding cost's bank lend money a low funding cost client?'. Contrary to popular wisdom, the answer is yes, thanks to the small FVA cost associated to a short term funding strategy

Finally, the introduction of the regulatory capital constraints will entail the need for contexstual capital increase (or equivalently to an allocation of an otherwise utilized capital) and the consequences are of a non-separability of FVA/KVA values.

XVA – Which point of view?

FVA, MVA, KVA, CVA, DVA they are commonly referred to XVA adjustment.

CVA
DVA

Due to the credit worthiness of the counterparties.
Part of the fair value of the product

FVA
MVA
KVA

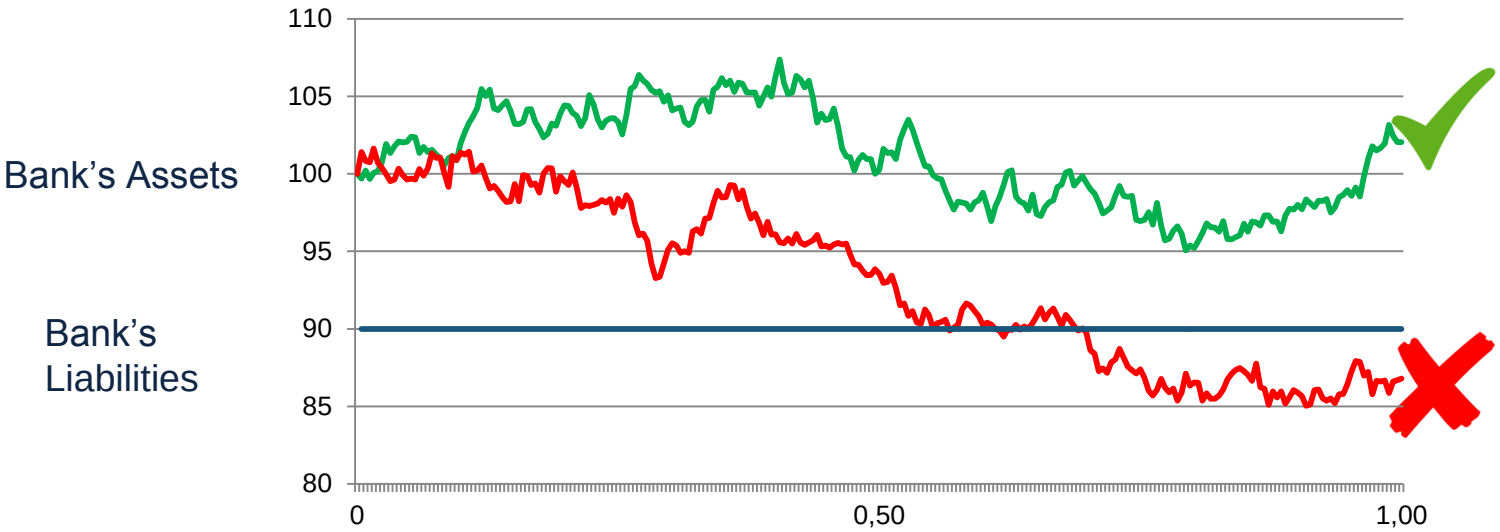
Due to the funding needs of the derivative.
Several actors within the bank have a different evaluation of their economic impact.
- Trading desk ?
- A bank subject which pays interests to debt end equity holders ?
- Equity holders ?

In our approach we will take the Equity holders point of view

Which Model?

To take the equity point of view is necessary to jointly model the evolution of the whole bank balance sheet and the derivative

Structural models can be used to achieve this.



We will use good old Merton model with a slight change of notations to highlight the impact of the financing strategies of the bank

The Model – Uniperiodic case

Let's assume the following:

- the risk measure is the risk neutral one (risk free rate is zero)
- the bank finance its assets A with a bond that expires at T
- the bank will default if $A(T) < LS_t$, where
    - $A(T)$ value of the bank assets at T
    - LS_t is the amount of debt and interests to be paid and
    - $S_t = 1 + \tau s_t$,
    - s_t is the funding spread set in t

The value of Equity in t is

$$E_t = \mathbb{E}_t[max(A(T) - LS_t, 0)]$$

The value of the Liabilities in t is

$$\mathbb{E}_t[min(A(T), LS_t)] = LS_t - \mathbb{E}_t[max(LS_t - A(T), 0)]$$

The Model – Uniperiodic case

The spread s_t is set by the creditor such that

$$L \leq LS_t - \mathbb{E}_t[max(LS_t - A(T), 0)]$$

→ the spread must be sufficient to remunerate the risks

In the following we will assume that the creditor is always «fair», i.e the minimum spread is applied:

$$L = LS_t - \mathbb{E}_t[max(LS_t - A(T), 0)]$$

N.B.
if s_t is fair → $E(t) = A(t) - L$

Proof

$$E(t) = \mathbb{E}_t[max(A(T) - LS_t, 0)] = \underbrace{A(t) - LS_t + \mathbb{E}_t[max(LS_t - A(T), 0)]}_{\text{Put-Call Parity}} = A(t) - L$$

A case for FVA/KVA

What is the impact of a new investment on the equity value of the bank?

Assets	Liabilities
A	L
	Equity
	E

Initial balance sheet

Assets	Liabilities
A A_1	$L + \Delta L$
	Equity
	$E(t_+)$

The day after: a new investment financed with new debt.
This investment can be of any type (note, derivative, etc…)

The question is: how much is $E(t_+) - E$?

The Model – Uniperiodic case

Let' s start with the case where the new investment is a risk free asset, i.e **cash** ($A_1 \equiv C$)

C doesn't depend upon t

Fair spread in t_+

$$E(t_+) = \mathbb{E}_{t+}\left[\max\left(\underbrace{A(T) + C}_{\text{Assets}} - \underbrace{LS_t - \Delta LS_{t_+}}_{\text{Liabilities}}, 0\right)\right]$$

The fair spead on the new debt must be such that:

$$C = \Delta L = \mathbb{E}_t\left[\Delta LS_{t_+}\mathbb{I}_{[A(T)+C>LS_t+\Delta LS_{t_+}]} + \underbrace{(A(T)+C)}\frac{\Delta L}{L+\Delta L}\mathbb{I}_{[A(T)+C<LS_t+\Delta LS_{t_+}]}\right]$$

In case of default the assets will be used for a partial reimburse proportionally to the face value of the liabilities

The Model – Uniperiodic case

Note that:

- $\Delta L = C$
- If $A_t \gg \mathrm{C} \rightarrow S_{t+} \approx S_t$

Hence, the variation in the equity value is

$$\mathbb{E}_t[\max(A(T) + C(T) - LS_t - \Delta LS_{t+}, 0)] - \mathbb{E}_t[\max(A(T) - LS_t, 0)] =$$

$$\approx -C \cdot \tau \cdot s_{t+} \cdot \mathbb{E}_{\boldsymbol{t}}\left[\mathbb{I}_{[\boldsymbol{A_T > L_t S_t}]}\right]$$

Bank's survival probabilty

This is the amount of money shareholders should require in order to invest borrowed money in a risk free asset

The Model – Uniperiodic case

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What if the asset is not risk free? The impact can negative («funding costs») or positive («funding benefits»), depending on the volatility and correlation with the existing assets.

$$E(t_+) = \mathbb{E}_{t+}\left[\max\left(A(T) + A_1(T) - LS_t - \Delta LS_{t_+}, 0\right)\right]$$

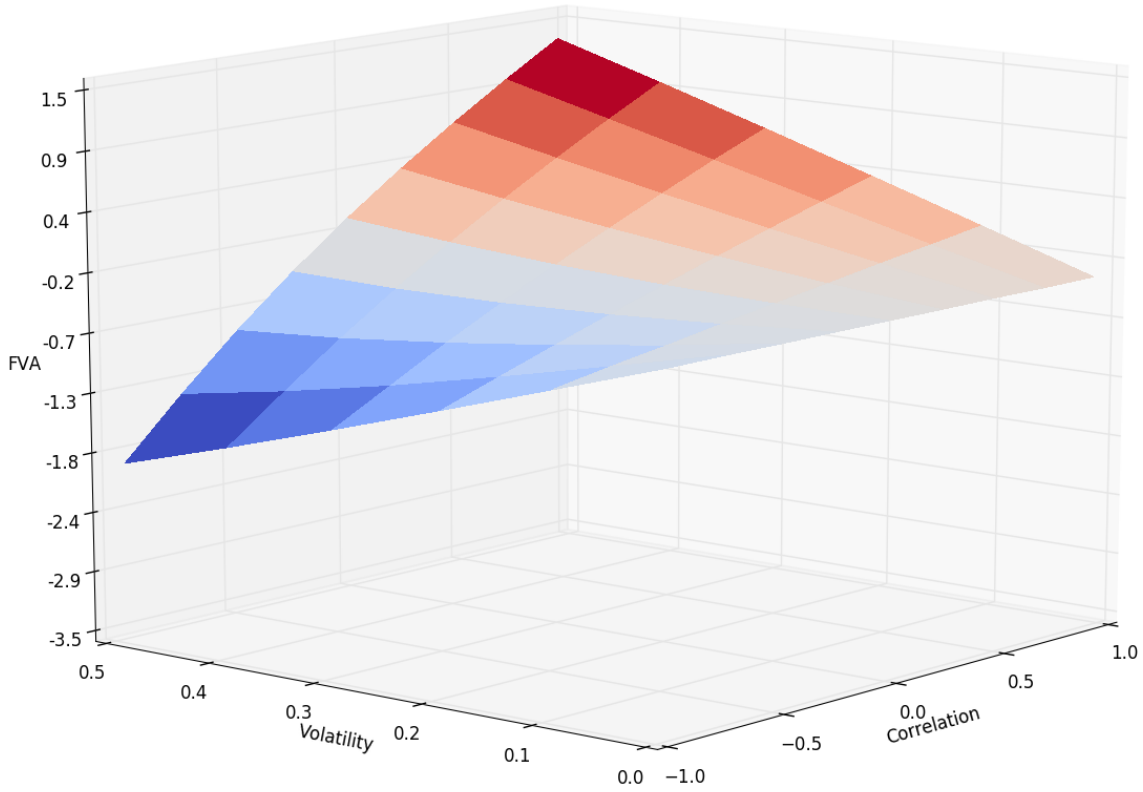
In general:

- $s_{t+} = f(A_1, \sigma, \sigma_1, \tau, \rho)$
- $\Delta E = g(A_1, \sigma, \sigma_1, \tau, \rho)$

We can draw some insights: the new marginal funding spread and the FVA (or put it differently the FTP charged by the treasury of the bank) depends on what the bank will invest in.
Higher variance of the total asset ($A + A_1$) higher will be the funding spread and lower the FVA.

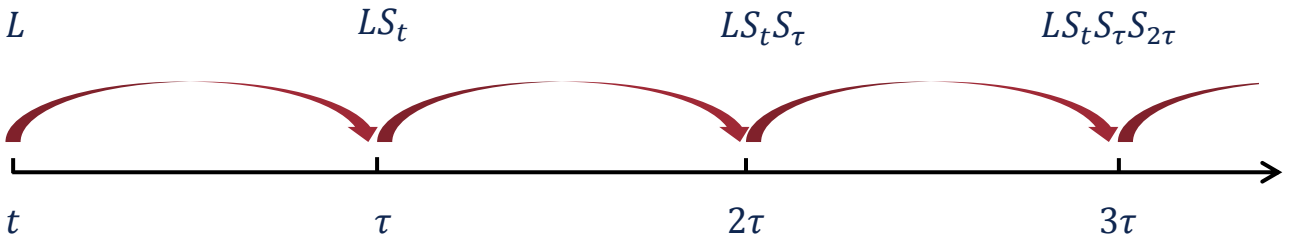
The Model – Uniperiodic case

$$A(t) = 100$$
$$\sigma_A = 20\%$$
$$L = 90$$
$$s_t = 6.60\%$$
$$\Delta L = A_1(t_+) = 10$$

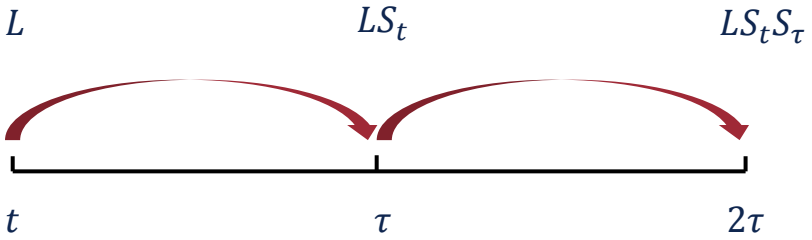


The Model – Multiperiodic case

In our multiperiodic settings we assume that the bank refinances all its debt as it expires.

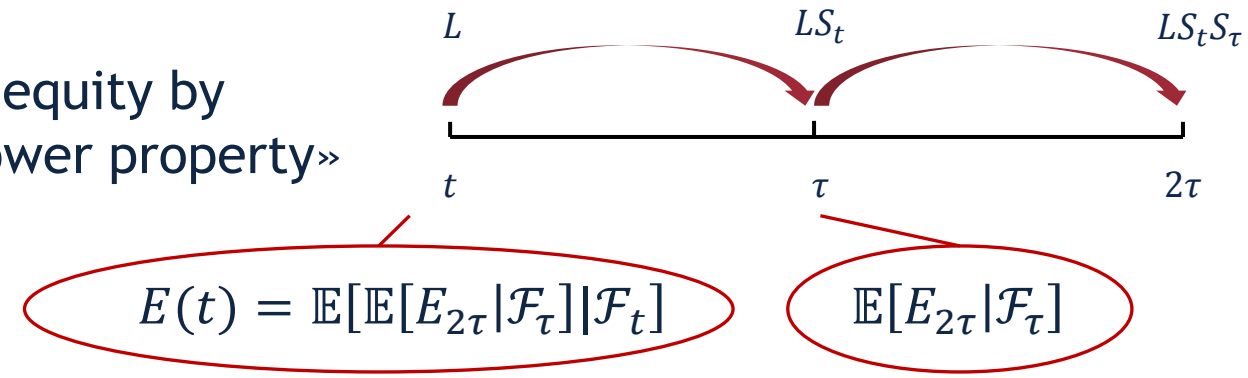


For the sake of simplicity, we analyze the case where the bank rolls its debt just once



The Model – Multiperiodic case

We evaluate the equity by means of the «tower property»



Let's look at the value of $\mathbb{E}[E_{2\tau}|\mathcal{F}_\tau]$ in the following 2 cases

$$A(\tau) \geq LS_t$$

The bank finance the debt + interest at a new fair spread.

$$\mathbb{E}[E_{2\tau}|A(\tau) > LS_t] = A(\tau) - LS_t$$

As in slide n.6

$$A(\tau) < LS_t$$

The bank **try to** finance the debt + interest at a new fair spread, but no one is willing to lend money…

$$\mathbb{E}[E_{2\tau}|A(\tau) \leq LS_t] = 0$$

Proof in the following slide

The Model – Multiperiodic case

Why if $A(\tau) < LS_t$ no one is willing to lend money?

Let's have a look at the fair value of the debt in the limit of an infinite spread

$$\lim_{S_\tau \to \infty} \mathbb{E}_\tau[\min(A(2\tau), LS_t S_\tau)] = \mathbb{E}_\tau[A(2\tau)] = A(\tau) < LS_t$$

→ The maximum fair value of the debt is always lower than the amount to be financed!

Combining the two cases we have that $\mathbb{E}[E_{2\tau}|\mathcal{F}_\tau] = \max(\mathrm{A}(\tau) - LS_t, 0)$

Therefore the equity can be priced as

$$E(t) = \mathbb{E}[\max(\mathrm{A}(\tau) - LS_t, 0)|\mathcal{F}_t]$$

→ *Exactly the same as in the uniperiodic setting*

The Model – Multiperiodic case

How is the FVA affected by the financing strategy of the bank?

Let's consider the purchase at time t_+ of a risk free asset whose maturity is greater than τ (the bond maturity), say 2τ

Applying the same reasoning as before, the change in the equity value is independent of the asset maturity, but only on the debt duration

$$E(t_+) = \mathbb{E}_{t_+}\left[\max\left(A(\tau) + C - LS_t - \Delta LS_{t_+}, 0\right)\right]$$

The FVA is proportional to the financing «period», not to the maturity of the asset, i.e. the following still holds!

$$FVA \approx -C \cdot \boldsymbol{\tau} \cdot s_t \cdot \mathbb{E}_t\left[\mathbb{I}_{[A_\tau > LS_t]}\right]$$

An application for FVA/MVA

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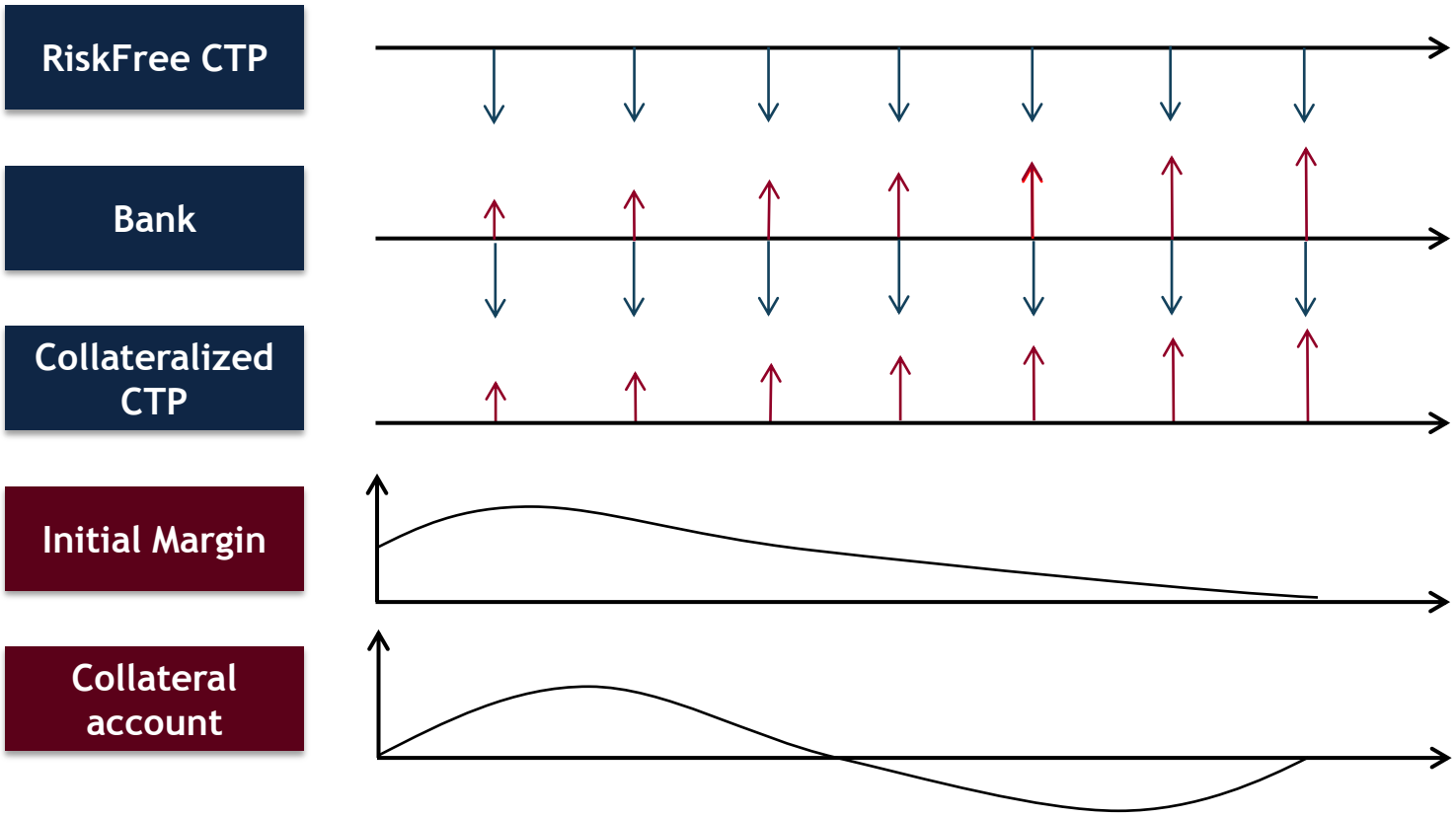
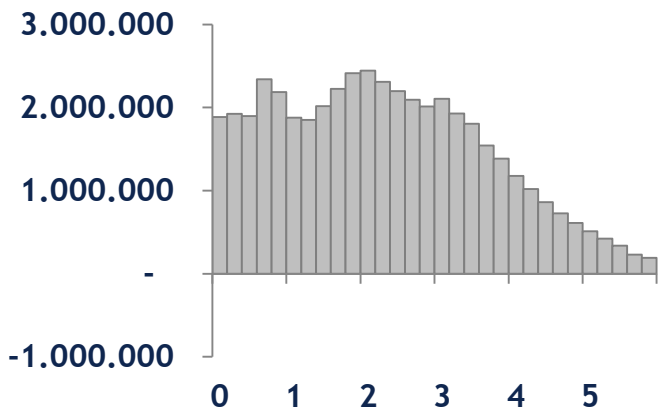
Suppose the bank enters in a back to back derivitave, one collateralized and one not. Which is the impact on the equity due to the funding of the collateral (Initial Margin and Variation Margin) in the multiperiodic case?



MVA – Uniperiodic case

In this case we can treat the initial margin as a cash account whose exposure varies (stochastically) through time.



IM(t) – Expected Initial Margin

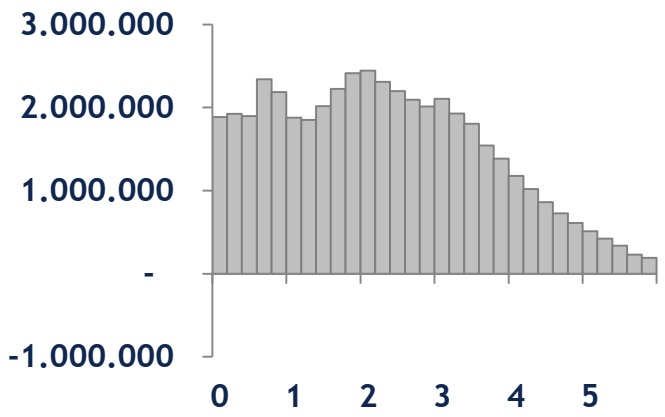
We assume that

- the maturity of the whole bank debt equal to the derivative's one
- the IM is uncorrelated with the total bank assets ($IM(t) \ll A(t)$)
- the fraction of cash coming back from the variation of IM account is used to buy back the bank's obligations

$$MVA_{uni} \approx -\mathbb{E}_t\left[\mathbb{I}_{[A_\tau > LS_t]}\right] \sum_{i}^{n:t_n \equiv T} IM(t_i) s_t (t_i - t_{i-1})$$

MVA – Uniperiodic case

In this case we can treat the initial margin as a cash account whose exposure varies (stochastically) through time.



IM(t) – Expected Initial Margin

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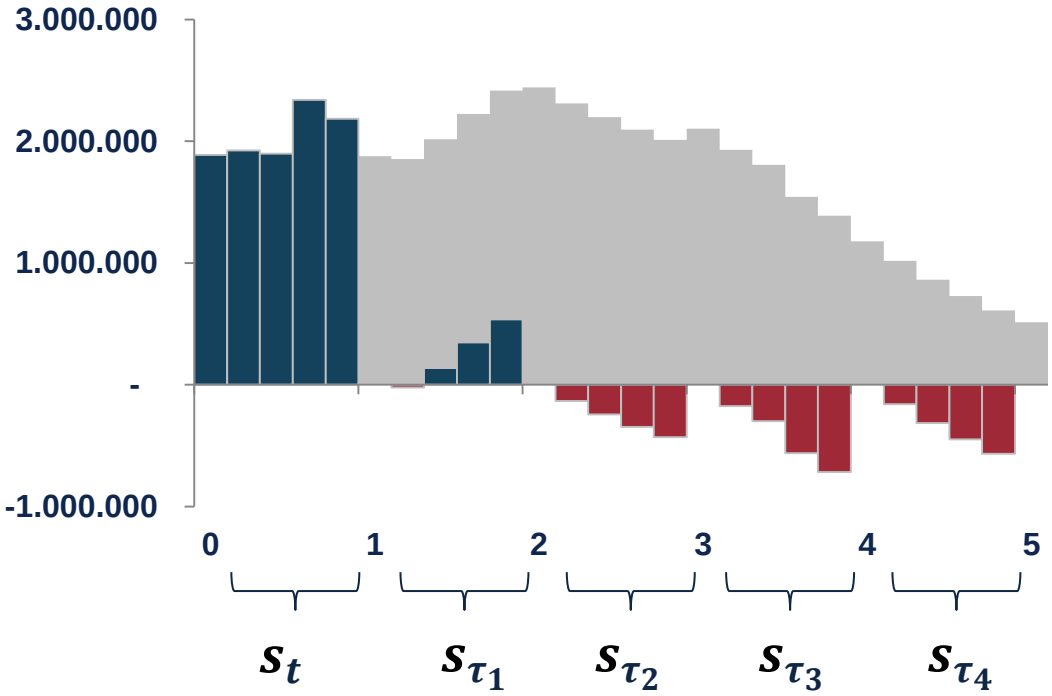
- the maturity of the whole bank debt equal to the derivative's one
- the IM is uncorrelated with the total bank assets ($IM(t) \ll A(t)$)
- the fraction of cash coming back from the variation of IM account is used to buy back the bank's obligations

Spread never resets

$$MVA_{uni} \approx -\mathbb{E}_t\left[\mathbb{I}_{[A_\tau > LS_t]}\right] \sum_{i}^{n:t_n \equiv T} IM(t_i) s_t (t_i - t_{i-1})$$

MVA – Multiperiodic case



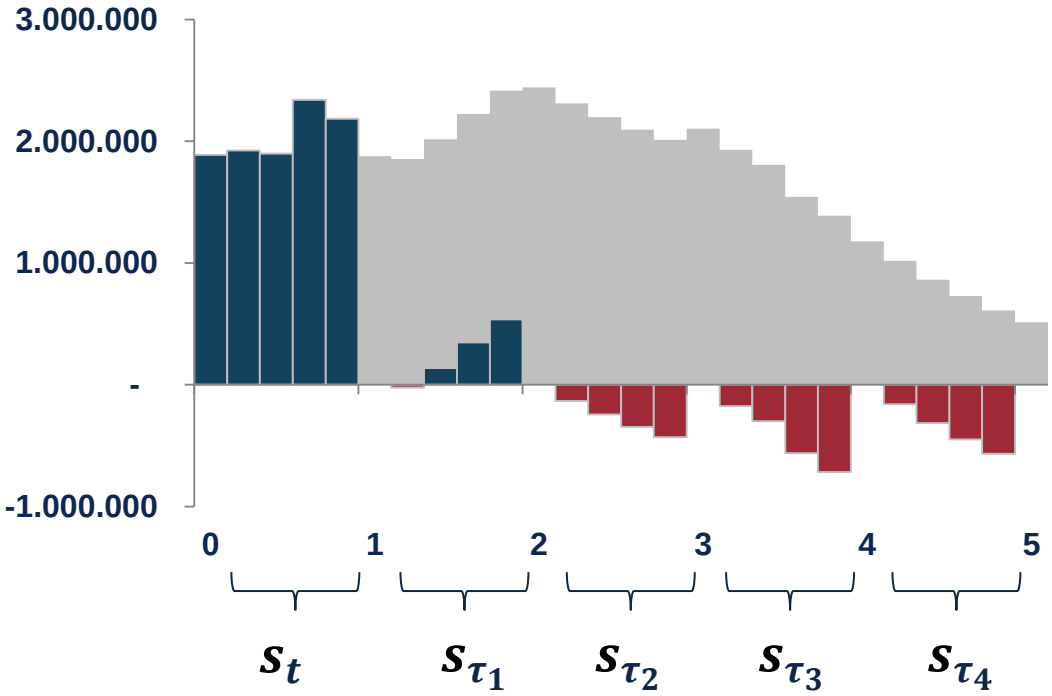
Spread resets at each refinancing date

Term similar to the uniperiodic case, but up to τ_1

$$MVA_{mult} \approx -\mathbb{E}_t[\mathbb{I}(A(\tau_1) > L_1] \sum_{i}^{n:t_n \equiv \tau_1} IM(t_i) s_t (t_i - t_{i-1}) +$$

$$- \sum_{j=2}^{n:\tau_n \equiv T} \left\{ \mathbb{E}_t \left[\mathbb{I}(A(\tau_j) > L_j) \sum_{i=1:t_1 \equiv \tau_{j-1}}^{n:t_n \equiv \tau_j} (IM(t_i) - IM(\boldsymbol{\tau_{j-1}})) s_{\tau_{j-1}} (t_i - t_{i-1}) \right] \right\}$$

MVA – Multiperiodic case



$$MVA_{multi} < MVA_{uni}$$

$$MVA_{mult} \approx -\mathbb{E}_t[\mathbb{I}(A(\tau_1) > L_1] \sum_{i}^{n:t_n \equiv \tau_1} IM(t_i) s_t(t_i - t_{i-1}) +$$

$$- \sum_{j=2}^{n:\tau_n \equiv T} \left\{ \mathbb{E}_t \left[\mathbb{I}(A(\tau_j) > L_j) \sum_{i=1:t_1 \equiv \tau_{j-1}}^{n:t_n \equiv \tau_j} (IM(t_i) - IM(\boldsymbol{\tau_{j-1}})) s_{\tau_{j-1}}(t_i - t_{i-1}) \right] \right\}$$

FVA for Collateral

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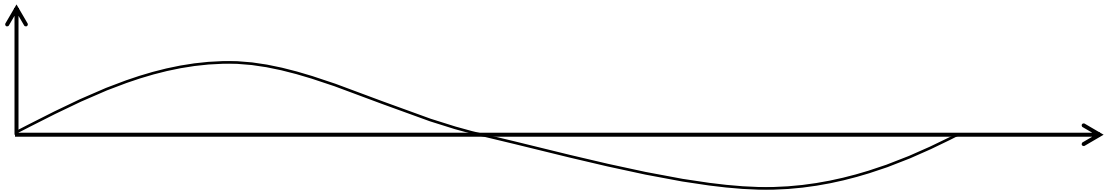
Collateral account



As for MVA, under the same assumptions, we treat the future exposure on the collateral account as non stochastic and take instead its expected exposure.

$$FVA_{uni} \approx -\mathbb{E}_t\left[\mathbb{I}_{[A_\tau > LS_t]}\right] \sum_{i}^{n:t_n \equiv T} EE(t_i) s_t (t_i - t_{i-1})$$

(*)

$$FVA_{multi} \approx -\sum_{j=1}^{n:\tau_n \equiv T} \left\{ \mathbb{E}_t \left[\mathbb{I}(A(\tau_j) > L_j) \sum_{i=1:t_1 \equiv \tau_{j-1}}^{n:t_n \equiv \tau_j} (EE(t_i) - EE(\tau_{j-1})) s_{\tau_{j-1}} (t_i - t_{i-1}) \right] \right\}$$

(*) These are proxy formulas valid in the case of a derivative traded with no payment in upfront.

KVA - Regulatory obligations

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Regulator requires the balancesheet of any bank to be respectful of predetermined ratios (mainly CET1 ratio).

Those constraints have an impact on the Equity levels over time, hence on the funding spread the market is applying at the end of each funding period.

What is the impact of the regulatory obligations on the ALM strategy of the bank? How does this affect the equity value (KVA)?

For the sake of simplicity, let the regulatory constraint be defined as

$$\frac{Equity}{\sum_i w_i Asset_i} \geq x\%$$

where x% is the regulatory ratio.
In reality, the numerator of the ratio is equal to the carrying value (historical value) of Own Funds, but in our case all assets are marked to market then our formulation is equivalent.

A case for FVA/KVA

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Hence, we will assume that:

- regulatory capital/CET1 is the equity value given by our structural model
- bank operates exactly on the regulatory threshold
- to fulfill the requirements, new capital will be raised and invested proportionally into existing assets
- creditors have perfect knowledge of the bank's balance sheet and the dynamics due to the regulatory obligations (i.e. capital raising)

A case for FVA/KVA

Assets	Liabilities
A	L
	Equity
	E

Initial balance sheet

$$\frac{E}{wA} = x\%$$

Assets	Liabilities
A A_1	$L + \Delta L$
	Equity
	E'

Purchase of an asset financed with new debt

$$\frac{\boldsymbol{E'}}{\boldsymbol{wA + w_1 A_1}} < \mathbf{x\%}$$

Assets	Liabilities
$A(1+\alpha)$ A_1	$L + \Delta L$
	Equity
	E''

Capital increase to continue business as usual

$$\frac{E''}{wA(1+\alpha) + w_1 A_1} = x\%$$

A case for FVA/KVA

Assets	Liabilities
A	L
	Equity
	E

Initial balance sheet

$$\frac{E}{wA} = x\%$$

Assets	Liabilities
A A_1	$L + \Delta L$
	Equity
	E'

Assets	Liabilities
$A(1+\alpha)$ A_1	$L + \Delta L$
	Equity
	E''

Assumption
Everything is done at the same time and there is perfect information

$$\frac{E''}{wA(1+\alpha) + w_1 A_1} = x\%$$

A case for FVA/KVA

This leads to the following equations problem

$$\frac{E(t)}{wA(t)} = \frac{E(\mathrm{t}_+)}{w(1+\alpha)A(\mathrm{t}_+) + w_1 A_1(t_+)} = x\%$$

$$E(\mathrm{t}_+) \longrightarrow \mathbb{E}_{t+}\left[\max(A_1 + (1+\alpha)A(\tau) - LS_t - \Delta LS_{t_+}, 0)\right]$$

$$A_1 = \Delta L = \mathbb{E}_{t+}\left\{\Delta LS_{t+}\mathbb{I}_{[not-defaulted]} + \frac{\Delta L}{L+\Delta L}\left[(1+\alpha)A(\tau) + A_1\right]\mathbb{I}_{[defaulted]}\right\}$$

A case for FVA/KVA

This leads to the following equations problem

$$\frac{E(t)}{wA(t)} = \frac{E(\mathrm{t}_+)}{w(1+\alpha)A(\mathrm{t}_+) + w_1 A_1(t_+)} = x\%$$

$$\mathbb{E}_{t+}\left[\max(A_1(\tau) + (1+\alpha)A(\tau) - LS_t - \Delta LS_{t_+}, 0)\right]$$

$$A_1(\mathrm{t}_+) = \Delta L = \mathbb{E}_{t+}\left\{\Delta LS_{t+}\mathbb{I}_{[not-defaulted]} + \frac{\Delta L}{L+\Delta L}[(1+\alpha)A(\tau) + A_1]\mathbb{I}_{[defaulted]}\right\}$$

- $\alpha A(t_+)$ is the amount of cash raised in the capital increase and reinvested in the existing asset
- s_{t_+} in $S_{t_+} = 1 + \tau s_{t_+}$ is the fair spread on the debt issued to purchase the new risky asset.
- s_{t_+}, α are the unknown variables which can be found by means of a root finding numerical algorithm.

A case for FVA/KVA

The impact on shareholders who were long equity at t is FVA&KVA

$$\text{FVA\&KVA} = E(t_+) - [E(t) + \alpha A(t_+)]$$

FVA and KVA are tightly bounded and represents two sides of the same coin…

HINT

To better understand the following numerical results it can be noted that a capital increase has always a negative impact on existing shareholders

In fact

$$\tilde{E}(t_+) = \mathbb{E}_{t+}\left[\max((1+\alpha)A(\tau) - K, 0)\right] \simeq E_t + \Delta BS \cdot \alpha A(t_+)$$

$$\Rightarrow \quad \text{KVA} = \tilde{E}(t_+) - [E(t) + \alpha A(t_+)] \simeq -(1 - \Delta BS) \cdot \alpha A(t_+)$$

A case for FVA/KVA – Numerical results

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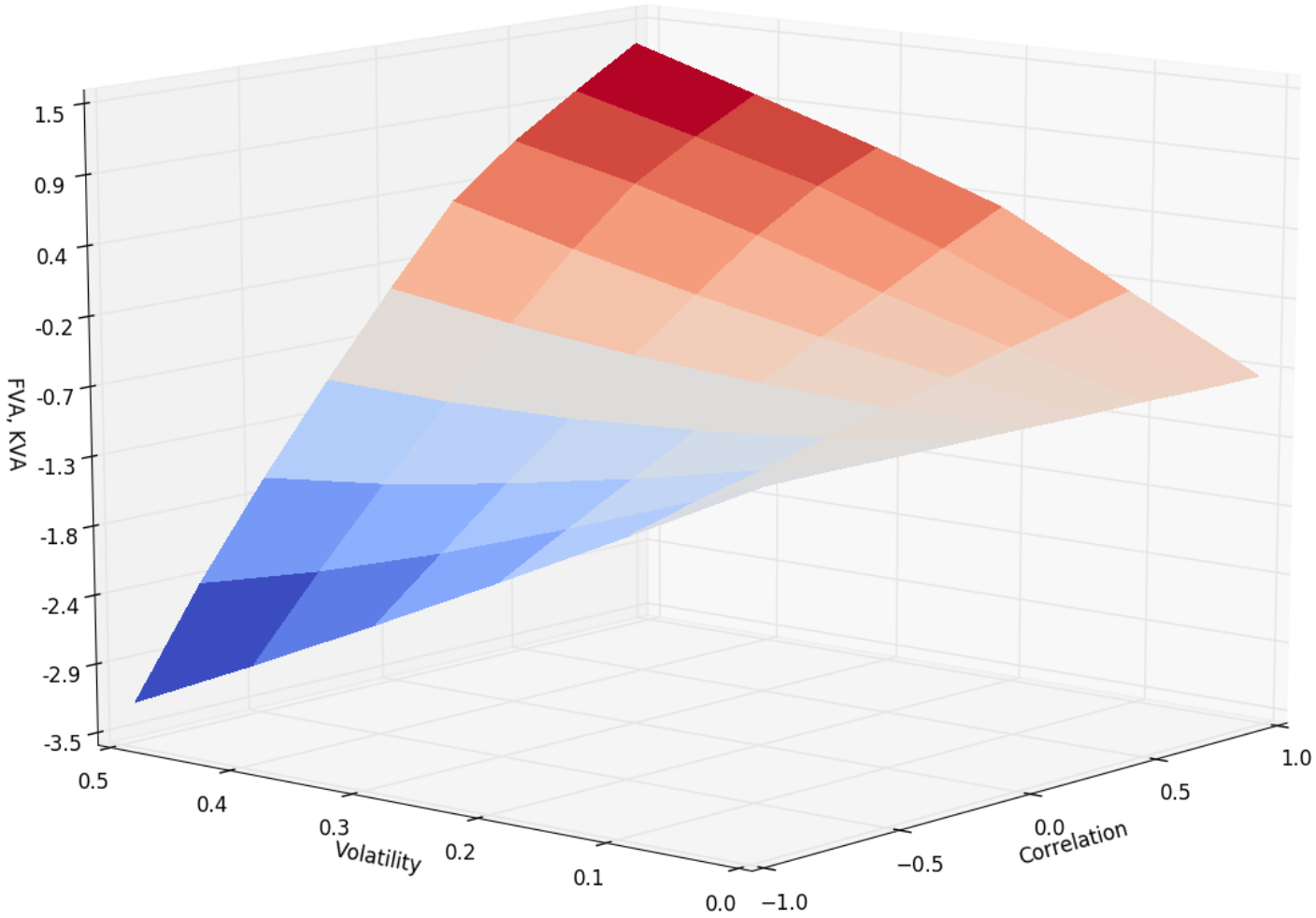
$$ratio = 10\%$$
$$A(t) = 100$$
$$\sigma_A = 20\%$$
$$L = 90$$
$$s_t = 6.60\%$$
$$\Delta L = A_1(t_+) = 10$$
$$w = 1$$
$$w_1 = 0.4$$



A case for FVA/KVA – Numerical results

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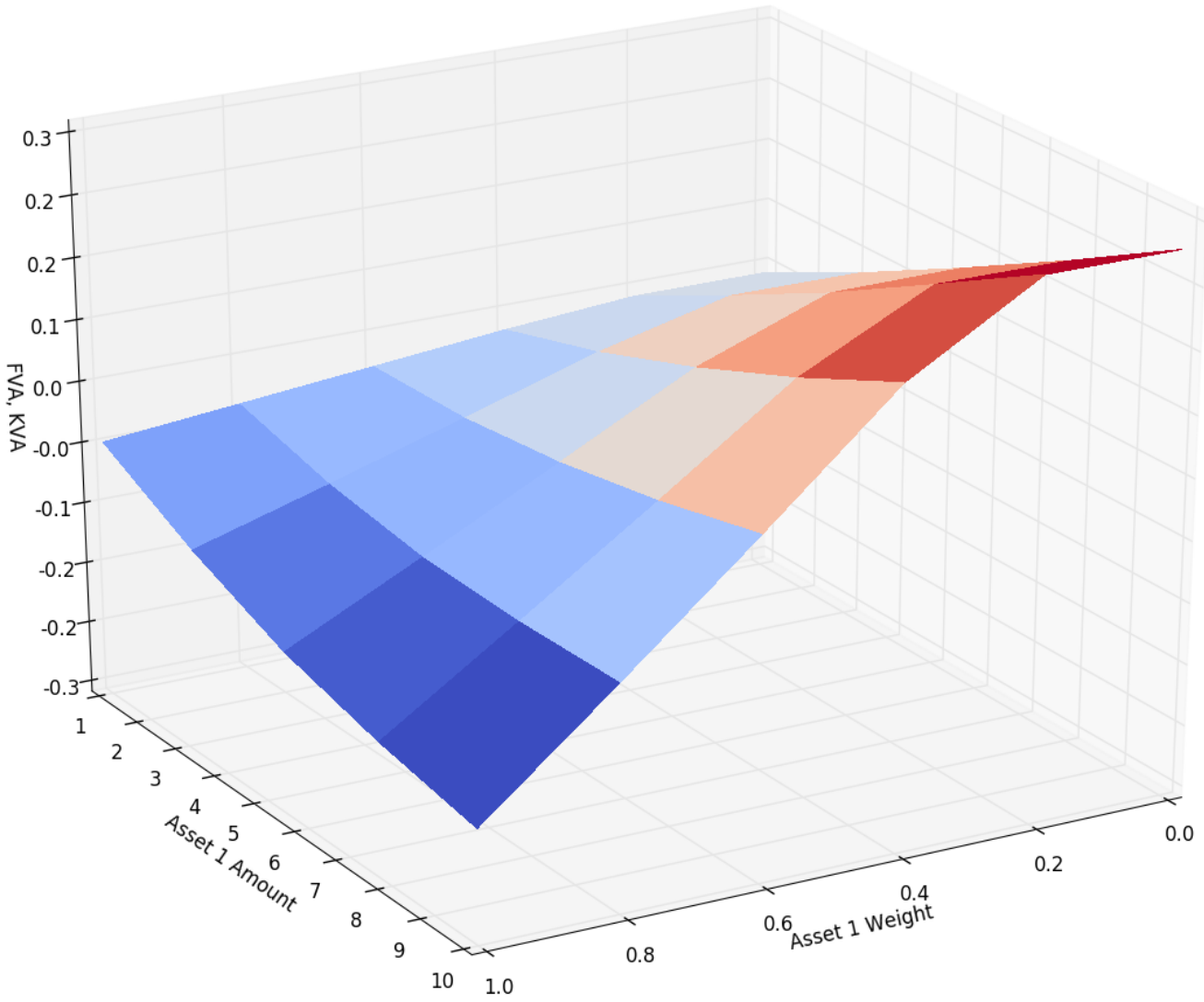
$ratio = 10\%$
$A(t) = 100$
$\sigma_A = 20\%$
$L = 90$
$s_t = 6.60\%$
$w = 1$
$\boldsymbol{\rho = 0.5}$
$\sigma_1 = 30\%$



A case for FVA/KVA – Numerical results

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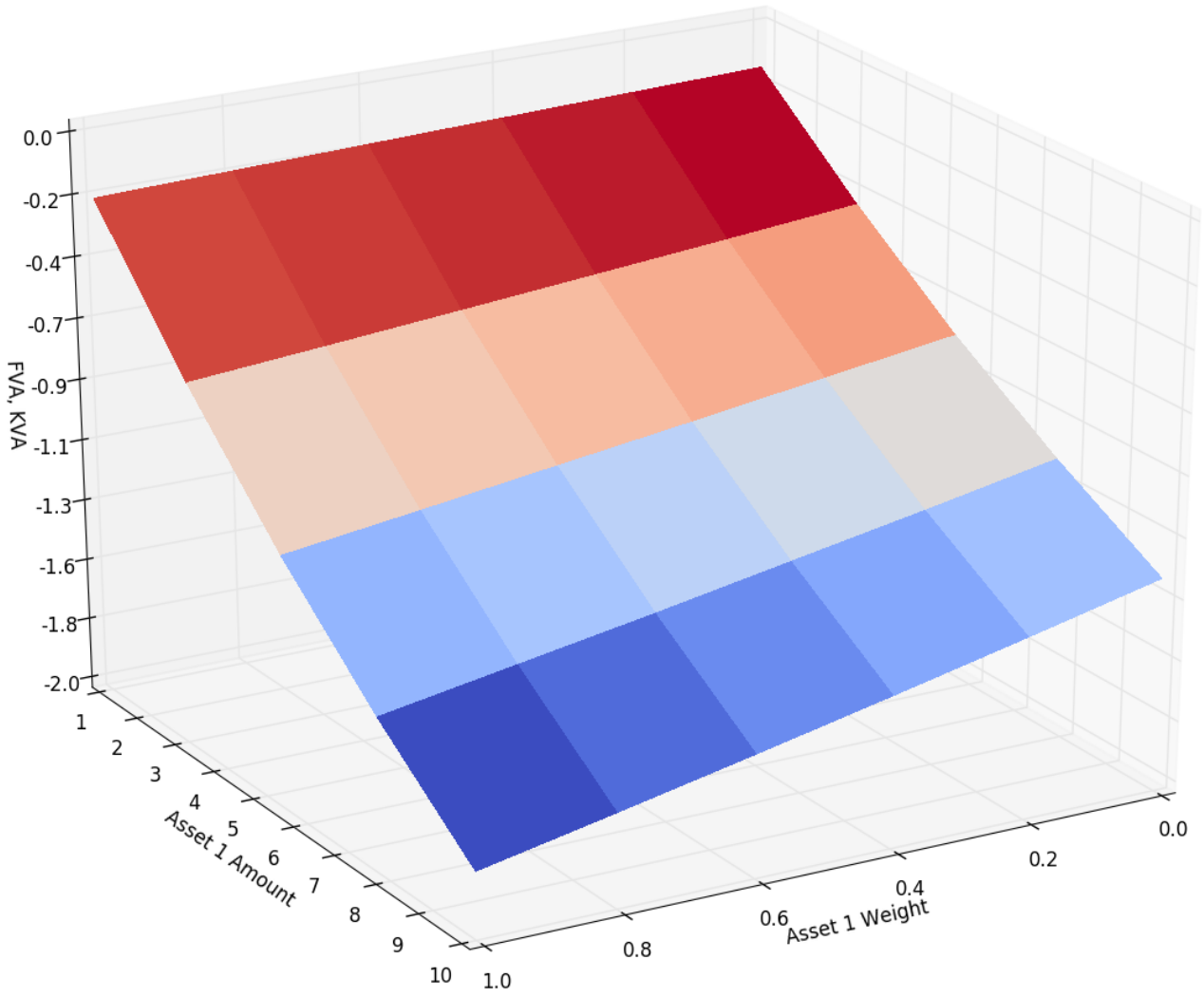
$$ratio = 10\%$$
$$A(t) = 100$$
$$\sigma_A = 20\%$$
$$L = 90$$
$$s_t = 6.60\%$$
$$w = 1$$
$$\boldsymbol{\rho = -0.5}$$
$$\sigma_1 = 30\%$$



A case for FVA/KVA – Numerical results

$$ratio = 10\%$$
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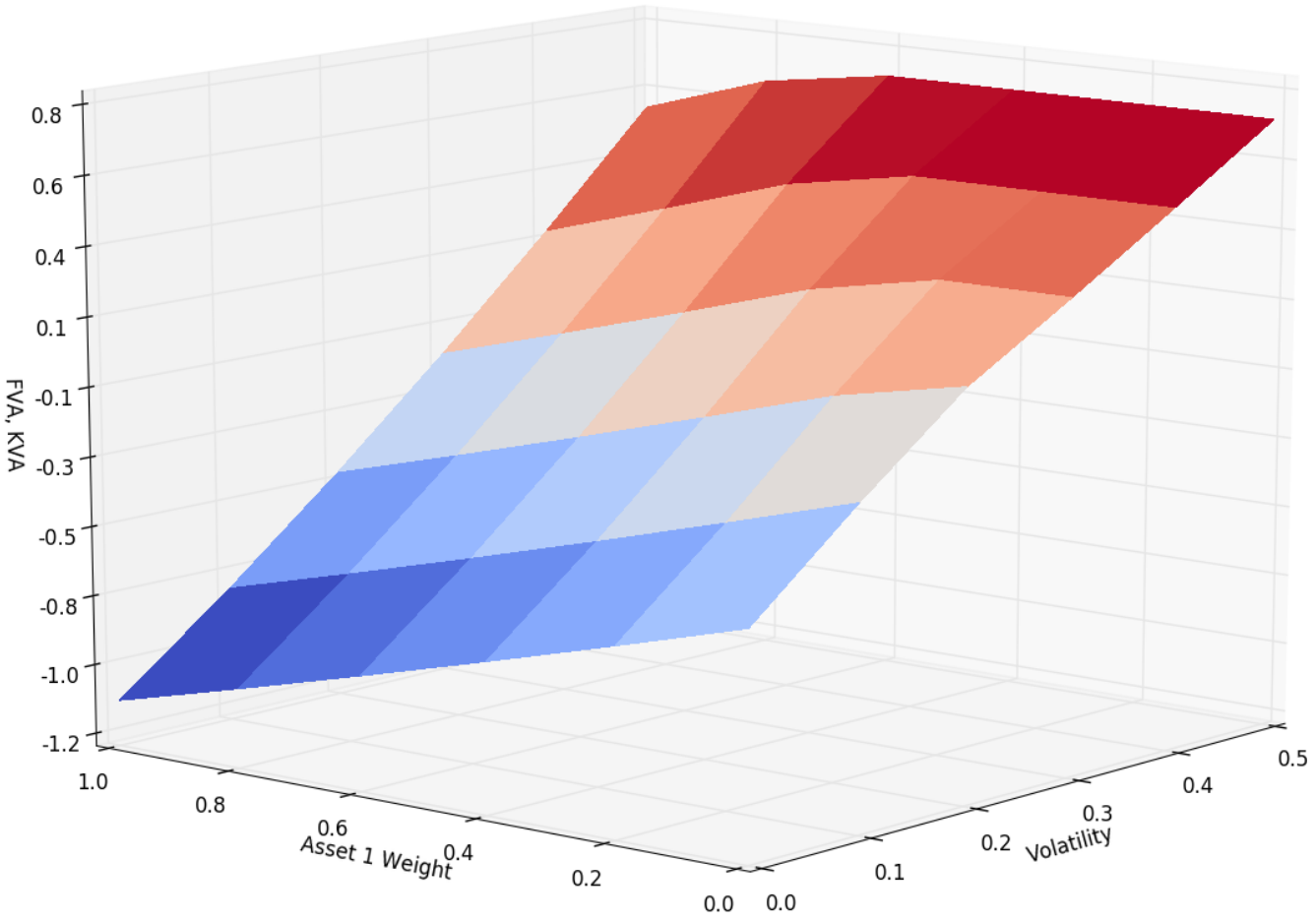
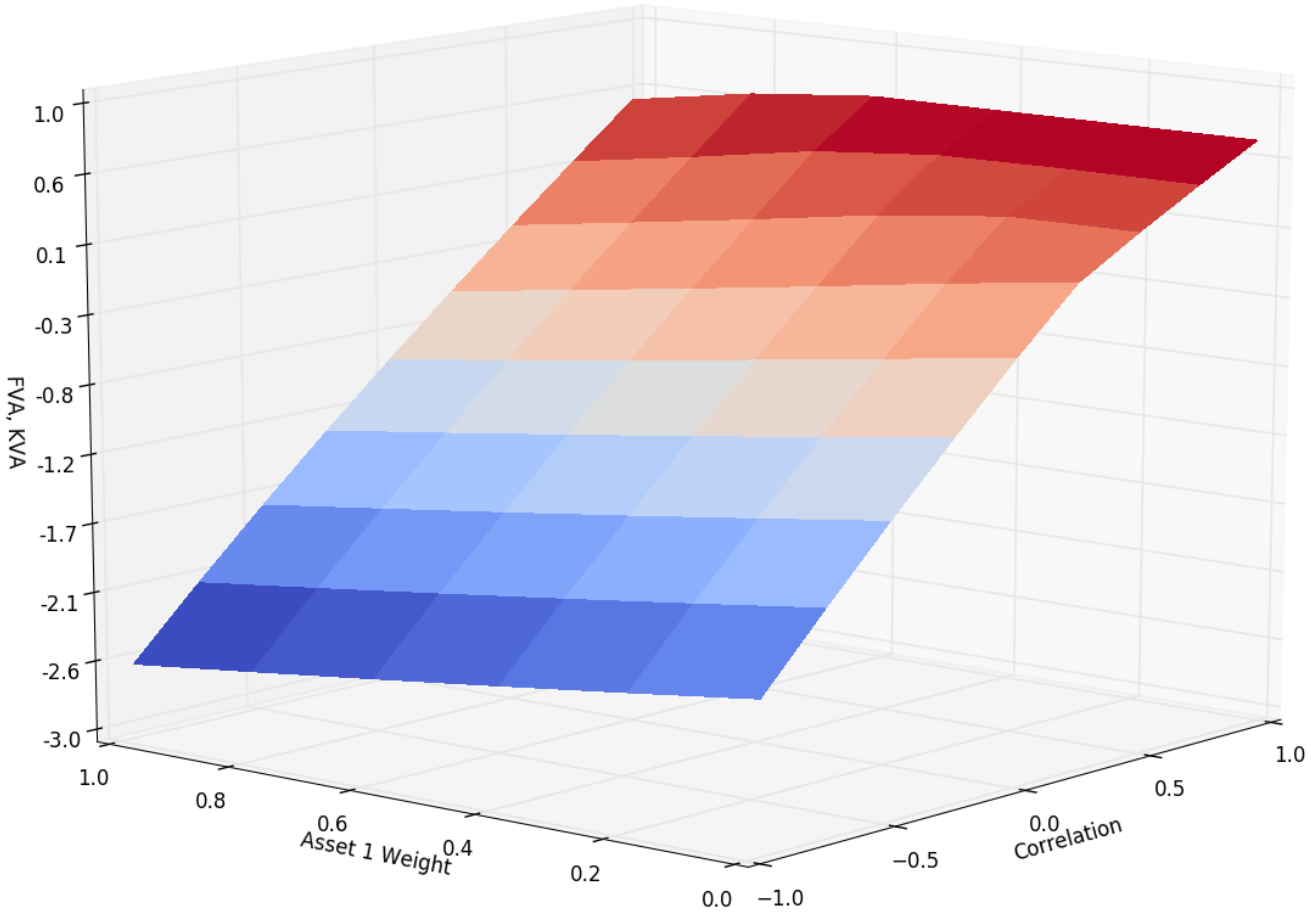
$$w = 1$$
$$\rho = 0.5$$



A case for FVA/KVA – Numerical results

$$ratio = 10\%$$
$$A(t) = 100$$
$$\sigma_A = 20\%$$
$$L = 90$$
$$s_t = 6.60\%$$
$$\Delta L = A_1(t_+) = 10$$
$$w = 1$$
$$\sigma_1 = 30\%$$



What's next

Real world is much more complex.

- Term structure of liabilities
- More realistic dynamic of the assets (for instance jumps)
- Is risk neutral the correct framework? In this approach all the adjustments are due to the volatility of the assets
- Regulatory constraints are much more complicated
- Balance sheet is not done at fair value for every asset/liabilities

Nonetheless…

Main models take away…

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- FVA, MVA, KVA impact on Equity depends on the **rolling frequency of the debt** and the **ability of the market to price properly the funding spread** at the time the debt is rolled.
- Change in volatility of the total assets is a driver to FVA/KVA adjsustments
- Once regulatory constraints are introduced it not possible to separate KVA and FVA components easily.
- Proof of concept on the **FTP**: instead of funding a business unit to a determined rate, units could be funded risk free and charged at a trade level for its impact on equity value.

Questions?

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