KVA: capital valuation adjustment by replication

Credit (CVA), debit (DVA) and funding (FVA) valuation adjustments are now familiar concepts, but banks also pay for capital. Here, Andrew Green, Chris Kenyon and Chris Dennis introduce a capital valuation adjustment (KVA) to pricing by extending the Burgard-Kjaer semi-replication method, considering that capital may reduce funding needs and hedging transactions themselves generate capital requirements.

Capital is a legal requirement for financial institutions holding derivatives, and the requirements have increased over the past few years (Basel Committee on Banking Supervision 2011; Dodd and Frank 2010), so it is surprising few papers include it in derivatives pricing (Hull and White 2014; Kenyon and Green 2013, 2014a,b). Here, we extend the hedging framework of Burgard and Kjaer (2011b, 2013a) and Kenyon and Kenyon (2013) to price the capital requirements of derivatives trades by replicating their cost, together with the costs of credit and funding. Thus, we present a capital valuation adjustment (KVA) alongside the existing adjustments for credit and funding.

Capital pricing appears challenging because there are hundreds of pages of regulations, lifetime costs are required (not just spot) and calculations at different levels of granularity must be combined. For example, for counterparty credit risk and credit valuation adjustment (CVA), capital netting sets are important, while the whole portfolio is needed to determine the stressed period for market risk for SVAR calculation. Table A gives a brief list of capital regulations in Basel III and the calculations required. However, this complexity does not introduce anything fundamentally new.

The two truly new elements in KVA, as compared with CVA or FVA, are that hedging trades themselves generate capital requirements and that capital may be used for funding. We include the capital requirements of hedges simply by always calculating the requirement of the entire portfolio. Furthermore, we introduce a parameter, \( \phi \), to represent the fraction of capital, \( K \), used for funding. Capital used for funding represents the use of funds from issued equity capital. Clearly \( \phi \in [0, 1] \).

Funding with capital reduces funding requirements. However, Basel III appears to prohibit explicitly linking capital issuance and its inverse to trading strategies. Thus, while a derivative can be funded by explicitly issuing and buying back bonds, specific derivatives or strategies cannot be funded by explicitly issuing and buying back capital. Of course, allocating varying amounts of capital to derivatives over their lifetime is required as their capital requirements change. In the numerical examples we consider two cases: the base case \( (\phi = 0) \) and full use of capital for funding \( (\phi = 1) \). We do not discuss the practicalities of different choices, but leave this for further research. Systematic and theoretical consequences are dealt with elsewhere (Kenyon and Green 2014a,b).

The main contribution of this paper is to extend the pricing picture by including the cost of capital, the KVA, in derivatives pricing by replication. Given the increased regulatory focus on capital post-crisis, continuing regulatory developments and their cost, this is long overdue.

### Extending semi-replication to capital

To include the cost of (regulatory) capital in pricing alongside credit and funding valuation adjustments, we extend the semi-replication argument of Burgard and Kjaer (2013a). This paper uses the notation of Burgard and Kjaer, and additions (table B). The sign convention is the value of a cash amount is positive if received by the issuer. As with Burgard and Kjaer, we seek to find the economic or shareholder value of the derivative portfolio, \( \hat{V} \). Note also that here, as with Burgard and Kjaer (2013a), we neglect balance sheet feedback effects as they are hard to realise, particularly when existing debt is issued at fixed coupons or spreads. Burgard and Kjaer studied balance sheet feedback in Burgard and Kjaer (2011a).

The dynamics of the underlying assets are:

\[
\begin{align*}
\frac{dS}{S} &= \mu dt + \sigma dW \\
\frac{dP_C}{P_C} &= r_C dt - \frac{\sigma^2}{2} C dt + \frac{\sigma}{2} dJ_C \\
\frac{dP_i}{P_i} &= r_i dt - (1 - r_i) P_i dJ_B \\
&\quad \text{for } i \in \{1, 2\}
\end{align*}
\]

On default of the issuer, \( B \), and the counterparty, \( C \), the value of the derivative takes the following values:

\[
\begin{align*}
\hat{V}(t, S, 1, 0) &= g_B(M_B, X) \\
\hat{V}(t, S, 0, 1) &= g_C(M_C, X)
\end{align*}
\]

The two \( g \) functions allow a degree of flexibility to be included in the model around the value of the derivative after default. The usual...
### B. A summary of the notation, which is also common with Burgard and Kjaer (2013)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V(t, S)$</td>
<td>The economic value of the derivative or derivative portfolio</td>
</tr>
<tr>
<td>$V$</td>
<td>The risk-free value of the derivative or derivative portfolio</td>
</tr>
<tr>
<td>$U$</td>
<td>The valuation adjustment</td>
</tr>
<tr>
<td>$X$</td>
<td>Collateral</td>
</tr>
<tr>
<td>$K$</td>
<td>Capital requirement</td>
</tr>
<tr>
<td>$\Pi$</td>
<td>Replicating portfolio</td>
</tr>
<tr>
<td>$S$</td>
<td>Underlying stock</td>
</tr>
<tr>
<td>$\mu_S$</td>
<td>Stock drift</td>
</tr>
<tr>
<td>$\sigma_S$</td>
<td>Stock volatility</td>
</tr>
<tr>
<td>$P_C$</td>
<td>Counterparty bond (zero recovery)</td>
</tr>
<tr>
<td>$P_i$; $P_2$</td>
<td>Issuer bond with recovery $R_1$; recovery $R_2$ (note $R_1 \neq R_2$)</td>
</tr>
<tr>
<td>$\delta \tilde{\delta} S; \delta \tilde{\delta} C; \delta \tilde{\delta} X; \delta \tilde{\delta} K$</td>
<td>Growth in the cash account associated with stock; counterparty bond; collateral; capital (all prior to rebalancing)</td>
</tr>
<tr>
<td>$r; r_C; r_i; r_X; r_F$</td>
<td>Risk-free rate; yield on counterparty bond; issuer bond; collateral; issuer bond (one-bond case)</td>
</tr>
<tr>
<td>$M_B; M_C$</td>
<td>Close-out value on issuer default; counterparty default</td>
</tr>
<tr>
<td>$\alpha_C; \alpha_i$</td>
<td>Holding of counterparty bonds; issuer bond</td>
</tr>
<tr>
<td>$\delta$</td>
<td>The stock position</td>
</tr>
<tr>
<td>$y_S$</td>
<td>Stock dividend yield</td>
</tr>
<tr>
<td>$q_S; q_C$</td>
<td>Stock repo rate; counterparty bond repo rate</td>
</tr>
<tr>
<td>$J_C; J_B$</td>
<td>Default indicator for counterparty; issuer</td>
</tr>
<tr>
<td>$g_B; g_C$</td>
<td>Value of the derivative portfolio after issuer default; counterparty default</td>
</tr>
<tr>
<td>$R_i; R_C$</td>
<td>Recovery on issuer bond; counterparty derivative portfolio</td>
</tr>
<tr>
<td>$\lambda_C; \lambda_B$</td>
<td>Effective financing rate of counterparty bond; issuer bond</td>
</tr>
<tr>
<td>$s_F; s_X$</td>
<td>Funding spread in one bond case; spread on collateral</td>
</tr>
<tr>
<td>$y_K(t)$</td>
<td>The cost of capital (the assets comprising the capital may themselves have a dividend yield and this can be incorporated into $y_K(t)$)</td>
</tr>
<tr>
<td>$\Delta \tilde{V}_B; \Delta \tilde{V}_C$</td>
<td>Change in value of derivative on issuer default; counterparty default</td>
</tr>
<tr>
<td>$\epsilon_B$</td>
<td>Hedging error on default of issuer (sometimes split into terms independent of and dependent on capital: $\epsilon_B = \epsilon_{b_0} + \epsilon_{b_2}$)</td>
</tr>
<tr>
<td>$P$</td>
<td>$P = \alpha_i P_i + \alpha_2 P_2$ is the value of the own bond portfolio prior to default</td>
</tr>
<tr>
<td>$P_D$</td>
<td>$P_D = \alpha_1 R_1 P_1 + \alpha_2 R_2 P_2$ is the value of the own bond portfolio after default</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Fraction of capital available for derivative funding</td>
</tr>
</tbody>
</table>

The risk-free value of the derivative or counterparty; issuer underlying stock is the valuation adjustment replicating portfolio collateral stock drift the stock position stock repo rate; counterparty bond repo rate the economic value of the derivative or stock volatility issuer bond with recovery issuer bond; collateral; issuer bond close-out value on issuer default; counterparty default holding of counterparty bonds; issuer bond the stock position stock dividend yield stock repo rate; counterparty bond repo rate default indicator for counterparty; issuer value of the derivative portfolio after issuer default; counterparty default recovery on issuer bond; counterparty derivative portfolio effective financing rate of counterparty bond; issuer bond funding spread in one bond case; spread on collateral the cost of capital the assets comprising the capital may themselves have a dividend yield and this can be incorporated into $y_K(t)$ change in value of derivative on issuer default; counterparty default hedging error on default of issuer (sometimes split into terms independent of and dependent on capital: $\epsilon_B = \epsilon_{b_0} + \epsilon_{b_2}$) $P = \alpha_i P_i + \alpha_2 P_2$ is the value of the own bond portfolio prior to default $P_D = \alpha_1 R_1 P_1 + \alpha_2 R_2 P_2$ is the value of the own bond portfolio after default fraction of capital available for derivative funding.

The risk-free value of the derivative or counterparty; issuer underlying stock is the valuation adjustment replicating portfolio collateral stock drift the stock position stock repo rate; counterparty bond repo rate the economic value of the derivative or stock volatility issuer bond with recovery issuer bond; collateral; issuer bond close-out value on issuer default; counterparty default holding of counterparty bonds; issuer bond the stock position stock dividend yield stock repo rate; counterparty bond repo rate default indicator for counterparty; issuer value of the derivative portfolio after issuer default; counterparty default recovery on issuer bond; counterparty derivative portfolio effective financing rate of counterparty bond; issuer bond funding spread in one bond case; spread on collateral the cost of capital the assets comprising the capital may themselves have a dividend yield and this can be incorporated into $y_K(t)$ change in value of derivative on issuer default; counterparty default hedging error on default of issuer (sometimes split into terms independent of and dependent on capital: $\epsilon_B = \epsilon_{b_0} + \epsilon_{b_2}$) $P = \alpha_i P_i + \alpha_2 P_2$ is the value of the own bond portfolio prior to default $P_D = \alpha_1 R_1 P_1 + \alpha_2 R_2 P_2$ is the value of the own bond portfolio after default fraction of capital available for derivative funding.

### Cutting edge: derivatives pricing

We assume the funding condition:

$$\hat{V} - X + \alpha_1 P_1 + \alpha_2 P_2 - \phi K = 0$$

where the addition of $\phi K$ represents the potential use of capital to offset funding requirements. The growth in the cash account positions (prior to rebalancing) are:

$$\delta \tilde{\delta} S = \delta(y_S - q_S) S dt$$

$$\delta \tilde{\delta} C = -\alpha_C q_C P_F dt$$

$$\delta \tilde{\delta} X = -r_X X dt.$$  

In the portfolio, $\Pi$, we account for two different sources of regulatory capital requirements: the derivative and the replicating portfolio. Positions in the stock and counterparty bond will themselves attract a capital requirement, hence:

$$K = K(t; V, 'market risk', X, C, \delta, \alpha_C).$$

that is, regulatory capital associated with the derivative is a function of the derivative portfolio value, its sensitivities through market risk capital, the collateral account value and the rating of the counterparty. The capital associated with the hedge portfolio is a function of the position in stock and bond. This reflects that regulatory capital applies to the whole derivative portfolio and not individual trades or counterparties. Some elements of the regulatory capital framework need to be attributed to portfolios from an overall net position. For example, market risk capital is calculated on the net position of all derivatives, while CVA capital under the standardised approach is calculated across all counterparties.

The change in the cash account associated with the capital position is:

$$d \tilde{\delta} K = -y_K(t) K dt$$

This treats capital as borrowed from shareholders to support derivative trading activities. The cost of capital is thus the cost of the return expected by shareholders for putting their capital at risk. In essence, the derivatives business borrows the capital and pays cash profits to the shareholders at a given rate. We do not include a $d J_B$ term for any impact of issuer default. This reflects that capital available to compensate creditors on issuer default is already part of the recovery rate.
We make the usual assumptions to eliminate the remaining sources of risk:
\[
\delta = -\frac{\partial \hat{V}}{\partial S}
\]  
and this leads to the PDE:
\[
0 = \frac{\partial \hat{V}}{\partial t} + \frac{\sigma^2 S^2}{2} \frac{\partial^2 \hat{V}}{\partial S^2} - (\gamma_S - q_S) S \frac{\partial \hat{V}}{\partial S} - (r + \lambda_B + \lambda_C) \hat{V} + g_C \lambda_C + g_B \lambda_B - \epsilon_h \lambda_B - s_X X - \gamma_K K + r \phi K
\]
\[V(T,S) = H(S)
\]
where the bond-funding equation (9) has been used, along with the yield of the issued bond, \(r_i = r + (1 - R_i) \lambda_B\), and the definition of \(\epsilon_h\) in equation (18) to derive the result:
\[
\alpha_{1} P_1 + \alpha_{2} P_2 = r X - (r + \lambda_B) \hat{V} - \beta \alpha (\epsilon_h - \beta) + r \phi K
\]
Note this paper assumes zero bond-CDS basis throughout.

Writing the derivative portfolio value, \(\hat{V}\), as the sum of the risk-free derivative value, \(V\), and a valuation adjustment, \(U\), and recognising that \(\hat{V}\) satisfies the Black-Scholes PDE:
\[
\frac{\partial V}{\partial t} + \frac{\sigma^2 S^2}{2} \frac{\partial^2 V}{\partial S^2} - (\gamma_S - q_S) S \frac{\partial V}{\partial S} - r V = 0
\]
\[V(T,S) = 0
\]
gives a PDE for the valuation adjustment:
\[
\frac{\partial U}{\partial t} + \frac{\sigma^2 S^2}{2} \frac{\partial^2 U}{\partial S^2} - (\gamma_S - q_S) S \frac{\partial U}{\partial S} - (r + \lambda_B + \lambda_C) U = V \lambda_C - g_C \lambda_C + V \lambda_B - g_B \lambda_B + \epsilon_h \lambda_B + s_X X + \gamma_K K - r \phi K
\]
\[U(T,S) = 0
\]
Formally applying the Feynman-Kac theorem gives:
\[
U = CVA + DVA + FCA + COLVA + KVA
\]
where:
\[
\begin{align*}
CVA &= -\int_t^T \lambda_C(u) e^{-\int_t^u (r(s) + \lambda_B(s) + \lambda_C(s)) \, ds} \times E_t[V(u) - g_C(V(u), X(u))] \, du \\
DVA &= -\int_t^T \lambda_B(u) e^{-\int_t^u (r(s) + \lambda_B(s) + \lambda_C(s)) \, ds} \times E_t[V(u) - g_B(V(u), X(u))] \, du \\
FCA &= -\int_t^T \lambda_B(u) e^{-\int_t^u (r(s) + \lambda_B(s) + \lambda_C(s)) \, ds} \times E_t[\epsilon_{h_0}(u)] \, du \\
COLVA &= -\int_t^T s_X(u) e^{-\int_t^u (r(s) + \lambda_B(s) + \lambda_C(s)) \, ds} \times E_t[X(u)] \, du
\end{align*}
\]

---

1 We also considered using capital to offset losses on counterparty default, which would lead to a term in \(\partial^1 C\) in equation (14). Symmetry would suggest that if capital can be used for funding then it could also offset losses on default. If we consider capital to be an exogenous resource and ignore the impact on the balance sheet, as is done in this paper, this is appealing. However, we rejected this as unrealistic. Losses do directly affect the balance sheet and hence capital. To fully understand the inter-relationship between counterparty default and capital requires a full balance sheet model.
Cutting edge: derivatives pricing

\[
KVA = -\int_0^T e^{-\int_0^t r(s) + \lambda_B(s) + \lambda_C(s)\,ds} \times E_t[\{\gamma_K(u) - r(u)\phi]K(u) + \lambda_B\delta_hK(u)\,du]
\]

(31)

FCA above contains only the classical non-capital dependent hedging error, while the capital-dependent terms have been grouped in KVA. Alternatively, we could have grouped the additional term in the KVA integral in the FCA integral to reflect the offset with funding:

\[
FCA' = -\int_0^T (\lambda_B(u)E_t[\delta_h(u)] - r(u)\phi)E_t[K(u)]) \times e^{-\int_0^t r(s) + \lambda_B(s) + \lambda_C(s)\,ds} \, du
\]

(32)

\[
KVA' = -\int_0^T \gamma_K(u)e^{-\int_0^t r(s) + \lambda_B(s) + \lambda_C(s)\,ds} \times E_t[K(u)\,du]
\]

(33)

Whatever arrangement is selected, the capital elements resolve to calculate integrals over the capital profile \(E_t[K(u)]\), which is strictly positive. We consider capital profile generation next.

Regulatory capital requirements and costs

Regulatory capital is a portfolio-level requirement. Consider an interest rate swap that is traded, unsecured, with a corporate client. This trade has market risk, counterparty credit risk and CVA capital requirements associated with it. To hedge the market risk the trading desk enters a collateralised offsetting swap with the street. This hedge trade generates a little counterparty credit risk and CVA capital, but drastically reduces the market risk capital. When pricing derivatives it is no longer sufficient to look at the impact of only the new trade. Instead, pricing increments of hedge packages is more appropriate. This will be illustrated in our numerical examples.

KVA itself, like CVA and FVA, has market risk sensitivities. The counterparty credit risk (CCR) term is driven by the exposure at default (EAD), and hence by the exposure to the counterparty. Capital requirements increase as exposure rises, irrespective of any impact on credit quality. KVA hedging involves using trades to generate retained profits to offset additional capital requirements arising from market moves. However, KVA hedges will again generate capital requirements, but because capital is generally a small fraction of O(1%), requirements converge quickly.

Table A gives an overview of Basel III (Basel Committee on Banking Supervision 2011) capital requirements calculation and we refer readers there for full details. Here, we will only consider the three main capital requirements to which most derivative trades are subject. That is, market risk capital, counterparty credit risk capital and CVA capital:

\[
K = K_{MR}(u, \frac{\partial V}{\partial u}) + K_{CCR}(u, V, C, X) + K_{CVA}(u, V, C, X)
\]

(34)

Market risk capital is a capital requirement to offset losses due to market movements for traded products (Basel Committee on Banking Supervision 2006), so we write it as a function of the sensitivity of the unadjusted value, \(V\). CCR is capital covering non-payment by counterparties and is calculated for over-the-counter derivatives as:

\[
RWA = w \times 12.5 \times EAD
\]

(35)

where \(w\) is the weight and EAD is the (regulatory) exposure at default of the counterparty. CVA capital was introduced by Basel III. Its European Implementation (CRD-IV) exempts EU-domiciled corporate counterparties, but is otherwise required.

**Cost of capital** The cost of capital represents the percentage return on regulatory capital that must be paid to shareholders. Thus the authors consider it an internal parameter set by the Bank's board in consultation with shareholders. Similar to funding, the cost of capital is idiosyncratic. A proxy is the return-on-equity (ROE) target in banks' annual reports. Rehbock et al. (2014) suggested a typical group ROE target might be 10%.

Numerical examples

Here, we provide example results to allow the impact of KVA to be assessed and compared with existing valuation adjustments, which were calculated using numeric integration of equations (27) through (31). We chose to calculate the case of semi-replication with no shortfall at own default, equivalent to 'strategy 1' in Burgard and Kjaer (2013a). We also chose the first issuer bond to have zero recovery, and use it to invest or fund the difference between \(V\) and \(V\'). The \(P_2\) bond position has recovery \(R_2 = R_B\) and is given by the funding constraint in (9). Hence:

\[
\alpha_1 P_1 = -U
\]

(36)

\[
\alpha_2 P_2 = -(V - \phi K)
\]

(37)

Using these hedge ratios gives the value of the issuer bond portfolio in default as:

\[
P_D = -R_B(V - \phi K)
\]

(38)

and hence \(\epsilon_h = \epsilon_{h_0} + \epsilon_{h_K}\) is then given by:

\[
\epsilon_h = (1 - R_B)[V^+ - \phi K]
\]

(39)

where:

\[
\epsilon_{h_0} = (1 - R_B)V^+ \quad \text{and} \quad \epsilon_{h_K} = -(1 - R_B)\phi K
\]

This choice gives the following formulas for CVA, DVA, FCA and KVA for regular bilateral closeouts:

\[
CVA = -(1 - R_C)\int_0^T \lambda_C(u)e^{-\int_0^t (\lambda_B(s) + \lambda_C(s))\,ds} \times E_t[\{e^{-\int_0^t r(s)\,ds}(V(u))^+\}]\,du
\]

(40)

\[
DVA = -(1 - R_B)\int_0^T \lambda_B(u)e^{-\int_0^t (\lambda_B(s) + \lambda_C(s))\,ds} \times E_t[\{e^{-\int_0^t r(s)\,ds}(V(u))^+\}]\,du
\]

(41)

\[\text{Note a similar situation has been avoided in the context of CVA capital for CDS spread hedges. Qualifying CDS positions designated as CVA hedges are exempt from further capital requirements.}\]
C. Counterparty data for the examples

<table>
<thead>
<tr>
<th>Counterparty</th>
<th>Rating</th>
<th>bp</th>
<th>Standardised</th>
<th>CVA</th>
<th>risk weight</th>
<th>w_i (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>30</td>
<td>20</td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>75</td>
<td>50</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BB</td>
<td>250</td>
<td>100</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCC</td>
<td>750</td>
<td>150</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D. XVA values for a 10-year, GBP, payer interest rate swap

\[
\begin{align*}
\phi & = - (1 - R_B) \int_0^T \lambda_B(u) e^{-\int_0^t \lambda_B(s) ds} \left( V(u) \right) du + \int_0^T \lambda_B(u) e^{-\int_0^t \lambda_B(s) ds} du \\
K_V & = - \int_0^T e^{-\int_0^t \lambda_B(s) ds} K(u)(y_K(u) - y_B(u)) \left( V(u) \right) du
\end{align*}
\]

where we have used the fact that \( r(u) + (1 - R_B) \lambda_B(u) = \lambda_B(u) \). This shows that in the event \( \phi \) is non-zero then the capital cost is reduced by the bank funding rate.

Since we consider an interest rate swap, interest rates are now assumed to be stochastic and so appear inside expectations. The derivation follows the same steps as for derivatives based on stocks (omitted here for space; see SSRN version).

Capital requirements: market risk uses the standardised approach; CCR uses the current exposure method for EAD, and the standardised approach with external ratings for weights; CVA uses the standardised approach with the approximation for large numbers of counterparties:

\[
K_{\text{CVA}} \approx \frac{2}{\pi} \sqrt{\text{Not} \cdot \text{M} \cdot \text{EAD}_{\text{final}}}
\]

We assume the issuer holds a minimum capital ratio requirement of 8% and the issuer cost of capital, \( y_K \), is 10%.

The examples are calculated using a single 10-year GBP interest rate swap with semi-annual payment schedules. The fixed rate on the swap is 2.7%, ensuring the unadjusted value is zero at trade inception. The issuer credit spread is a flat 100 basis points across all maturities and the issuer recovery rate is assumed to be 40%.

We calculate all valuation adjustments for four different counterparty ratings and spread combinations: AAA, A, BB and CCC. The spreads are given in Table C alongside the risk weight. The counterparty recovery rate is assumed to be 40%.

Table D presents the results for a 10-year, GBP, payer interest rate swap. Setting aside the market risk component of the capital, we see the CVA from CCR and CVA terms gives similar adjustments to existing CVA, DVA and FCA terms, demonstrating CVA is a significant contributor to the price of the derivative.

The market risk is assumed to be unhedged, so this CVA component is relatively large, because under the standardised approach, the capital requirement on a 10-year transaction of this type is scaled to a 60bp move in rates. Practical application would calculate the market risk capital requirement over all trades in a portfolio, including hedges, and attribute them to trade level. The cases where capital is used for funding, \( \phi = 1 \), show a reduction in capital costs.

To assess the impact of hedging, the second example consists of two back-to-back interest rate swaps (see Table E). The hedge trade is the exact mirror of the primary trade and perfectly collateralised, so it has no CVA, DVA, FCA or collateral valuation adjustment (ColV A). The market risk capital will be zero as the swaps match exactly and hence can be removed from market risk capital under Basel. However, the other CVA terms are not zero. In addition, although the portfolio has no market capital requirement, it has an open market risk position from the valuation adjustment terms and the portfolio IR01 is given in the final column.

If, instead of using a back-to-back hedge, the net portfolio market risk is eliminated at trade inception with a static hedge, the portfolio will have an IR01 of zero at the start. However, it still attracts market risk capital as the trade and hedge do not match exactly. This is illustrated in Table F. Again, for the hedge trade, we assume perfect collateralisation.
We have presented a unified model for valuation adjustments, which includes the impact of capital, and introduced a new ‘XVA’ term called KVA. Practical examples of KVA on an interest rate swap have demonstrated how significant capital costs are, and that KVA is broadly similar in size to the other components of XVA. The use of capital to reduce KVA is reduced by around one-third. Where the market risk capital is non-zero, the KVA associated with it is also reduced by approximately one-third.

Conclusions
We have presented a unified model for valuation adjustments, which includes the impact of capital, and introduced a new ‘XVA’ term called KVA. Practical examples of KVA on an interest rate swap have demonstrated how significant capital costs are, and that KVA is broadly similar in size to the other components of XVA. The use of capital to reduce funding requirements results in reductions in KVA of around one-third (we grouped all capital-related effects into KVA in the examples). However, it is unclear in practice whether this option will be available to a derivatives trading desk. In as much as this reflects a divergence of practice from actual effects, some reassessment may be required.

The implication of the introduction of KVA is that just like CVA and FVA, it should be managed and hedged. KVA can be aligned with the counterparty, and clearly has contingency on the survival of the counterparty and issuer. The most appropriate approach would be to manage KVA alongside CVA and FVA at portfolio level in a central resource-management desk.

Andrew Green is the head of the CVA/FVA quantitative research team at Lloyds Banking Group in London. Chris Kenyon and Chris Dennis are directors in the same team. The authors would like to thank Lincoln Hannah, Glen Rayner and the two anonymous referees for their contributions. The views expressed are those of the authors only and no other representation should be attributed.

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